A River Running in the Desert: Lessons for Integrated Water Resources Management from the San Pedro HELP Basin on the U.S.-Mexico Border

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Abstract:

Flowing from Mexico into the United Status, the San Pedro Basin sits within an intermountain ecotone with the Sonoran and Chihuahuan Deserts to the west and east. As the region's only remaining perennial stream, the San Pedro River serves as an international flyway for over 400 bird species. One of the western hemisphere's most ecologically diverse areas, the basin contains some 20 different biotic communities, supports endangered plants and animals, and "possesses one of the richest assemblages of land mammal species in the world." Large mining, military, and municipal entities are major users of the same groundwater resources that maintain perennial flow in the San Pedro. This paper provides empirical evidence of the positive impacts on watershed management of scientists and policy researchers working closely with water managers and other stakeholders in a functioning HELP basin. We argue that transboundary cooperation in policymaking and water management is most effective when hydrologists help watershed groups understand the processes controlling water quality and quantity, and when managers and stakeholders connect these processes to social, economic and legal issues. We assess the distinctive nature of the Basin in terms of its physical and socioeconomic characteristics, as well as differences in institutional regulations, water law issues, and local implementation in Arizona and Sonora. We demonstrate how stakeholders and scientific researchers in both countries strive to balance ecosystem needs with human demands to create new, integrated basin management. Finally, we offer to the HELP agenda the accomplishments of this collaborative process—including the use of environmental-conflict-resolution tools—and the lessons learned from the San Pedro HELP Basin experience.

Key words: transboundary watershed, IWRM, sustainable water resources management

INTRODUCTION

Flowing from Mexico into the United Status, the San Pedro Basin sits within an intermountain ecotone with the Sonoran and Chihuahuan Deserts to the west and east respectively. As the region's only remaining perennial stream, the San Pedro River serves as an international flyway for over 400 bird species. One of the western hemisphere's most ecologically diverse areas, the basin contains some 20 different biotic communities, and supports endangered plants and animals. Large mining, military, and municipal entities are major users of the same groundwater resources that maintain perennial flow in the San Pedro. This paper provides empirical evidence of the positive impacts on watershed management of scientists and policy researchers working closely with water managers and other stakeholders in a functioning HELP

basin. The authors argue that transboundary cooperation in policymaking and water management is most effective when hydrologists help watershed groups understand the processes controlling water quality and quantity, and when managers and stakeholders connect these processes to social, economic and legal issues. They assess the distinctive nature of the Basin in terms of its physical and socioeconomic characteristics, as well as differences in institutional regulations, water law issues, and local implementation in Arizona and Sonora. They demonstrate how stakeholders and scientific researchers in both countries strive to balance ecosystem needs with human demands to create new, integrated basin management. Finally, they offer to the HELP agenda the accomplishments of this collaborative process—including the use of environmental-conflict-resolution tools—and the lessons learned from the San Pedro HELP Basin experience. Some of this presentation is based upon the authors' publication in 2006 of Integrating Science and Policy for Water Management: A case study of the Upper San Pedro River Basin in *Hydrology and Water Law — Bridging the Gap: A Case Study of HELP Basins*

Physical characteristics

The Upper San Pedro River Basin, located in the semi-arid borderof south-eastern Arizona and north-eastern Sonora (Figure 1), lies entirely within the "Basin and Range" physiographic province, a region of steep, elongated, north-south running mountain ranges separated by wide, flat, arid or semi-arid valleys, extending from eastern California to central Utah, and from southern Idaho into the state of Sonora in Mexico. The Basin comprises a broad, high-desert valley bordered by mountain ranges and bisected by a narrow riparian corridor sustained by groundwater discharge. The basin has a variety of characteristics that makes it an exceptional outdoor laboratory to address a large number of scientific and socioeconomic challenges germane to the aim of HELP. The upper watershed encompasses an area of approximately 7600 km^2 with approximately 1800 km^2 of that area in Mexico.

Annual precipitation in the Upper San Pedro River Basin ranges from around 300 mm in the lower and northern portions of the basin to over 750 mm in the Huachuca and Catalina mountains. Approximately 65 percent of this typically occurs during the July through September monsoon season from high intensity air-mass convective thunderstorms. Roughly 30 percent comes from less intense winter frontal systems. Potential evapotranspiration is estimated at more than ten times annual rainfall at lower elevations in the basin (Renard *et al*., 1993). Interannual climate variability is also high with a demonstrated linkage to the El Niño-Southern Oscillation (Woolhiser *et al*., 1993). Landcover in the basin changed dramatically in the period between 1973 and 1986, with mesquite woodlands increasing from 2.75 percent to 14.05 percent, largely replacing desert grasslands (Arias, 2001: 6-7; Kepner *et al*., 2002: 187; Stromberg and Tellman, in press). These changes are largely attributable to climatic fluctuations, livestock grazing, and

more recently, rapid urbanization affecting fire regimes and other factors.

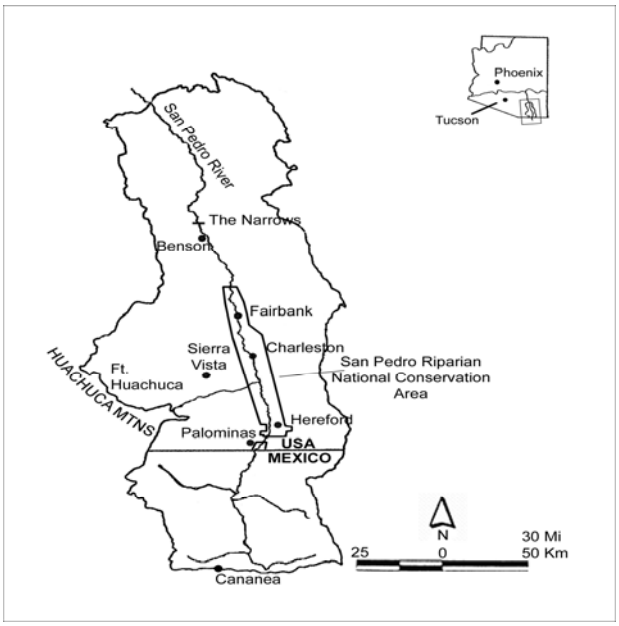

Figure 1 Upper San Pedro River Basin, Arizona (U.S.) and Sonora (Mexico) (Source: Sprouse 2005:12)

Population and socio-economic characteristics

Approximately 115,000 people live and work in seven incorporated towns and several unincorporated communities in the two countries within the Upper San Pedro River Basin. Principal economic drivers in the valley include the U.S. Army's Fort Huachuca on the Arizona side of the border and the copper mines near Cananea on the Sonora side (CEC, 1999). Population in the Mexican portion of the Upper San Pedro River Basin is mainly concentrated in Cananea and Naco. Most of Cananea's 36,000 residents (INEGI, 2003) depend economically on the copper-mining operation that has been there for over a 100 years. This mine represents the largest single source of water consumption in the watershed. However, groundwater availability is essential to sustain the ranching and agriculture in the Mexican portion of the basin as well. Approximately nine *ejidos*, or communal agricultural settlements, are dispersed across the Mexican subwatershed. Closer to the border, the municipality of Naco has approximately 5,300 residents, which can swell to 7,000 with transient workers waiting to cross into the United States. North of the border, population is concentrated near the city of Sierra Vista, with 40,000 residents, drawn largely from the military base and retirees (Varady *et al*., 2000).

Critical problems and challenges: differences in institutional regulations, water law issues, and local implementation in Arizona and Sonora.

In the face of continued population growth, there is great concern over the long-term viability of the San Pedro riparian system. Groundwater sustains the system throughout its length

during dry seasons. A predicted decline in northern Mexico's water availability not only might threaten the viability of the San Pedro River but also might exacerbate the increasing competition for water resources between productive sectors such as agriculture and industry and domestic consumption (Magaña and Conde, 2001: 1). In fact, the threat of excessive groundwater pumping within this riparian system prompted the first application of international environmental law within the United States via the environmental side accord of the North American Free Trade Agreement. In the resulting fact-finding report, *Ribbon of Life*, the CEC-appointed technical-expert team recommended the creation of a Coordinated Resource Management Program to develop a transboundary basin water-planning and management plan (CEC, 1999).

One of the most distinctive challenges of the basin is the difference in laws governing water management and allocation in the two portions of the basin. Mexican water management traditionally has been carried out in a centralized manner from Mexico City, with large regional watershed districts linked both to state governments and to Mexico City. Devolution of responsibility for watershed management from state and regional levels to watershed and municipal levels has been slow and somewhat problematic because the task is large and the budget to implement this task is small. More recent water laws in the United States, especially in the West, also have shifted the focus to the watershed level with multiple stakeholder and agency involvement. But the concept of private and unregulated water rights based on state laws in the West, including Arizona, may inhibit this shift, which may be more enabled by federally reserved water rights, Section 321 to federal defense spending, the federal Endangered Species Act , and modern Active Management Areas or Irrigation Non-Expansion Areas for groundwater in Arizona. Many state water laws manage water as private property rather than a common pool resource (Glennon, 2004:1). Theoretically, Mexican water is managed as a common pool resource with water use rights determined by the government through the Mexico National Water Commission (CNA), but just how different such water management is from that in western United States in the will depend on how permanent and privately controlled the rights issued by the CNA will be.

The effect of these basin differences is seen in the disparity in the level of local watershed organization. The major water stakeholder organization in Arizona, the Upper San Pedro Partnership has working for over ten years "to coordinate and cooperate in the identification, prioritization and implementation of comprehensive policies and projects to assist in meeting water needs … to protect the people and natural resources of the Sierra Vista Sub-watershed… [and] to ensure an adequate long-term groundwater supply is available to meet the reasonable needs of both the area's residents and property owners (current and future) and the San Pedro Riparian National Conservation Area (SPRNCA)" (Upper San Pedro Partnership, 2000: 2). The Partnership's organizational structure, membership composition and method of operation have demonstrated an effective approach in breaking the "paradigm lock" identified by the HELP initiative. Their approach is an adaptive management process wherein annual plans are refined

based on the best science currently available to policymakers. A major challenge in addressing their mission was to quantify water needs for the SPRNCA. Decision-makers needed sound science to provide guidance as to what "success" might look like for the San Pedro River in hydrologic terms; how else could they know whether their objectives in terms of the river had been met? To address this information need, members of the Partnership, including scientists and decision-makers, crafted a three-year interdisciplinary research project that would:

- determine temporal and spatial water needs of riparian vegetation within the SPRNCA to ensure its long-term ecological integrity;
- quantify total consumptive water use of riparian vegetation within the SPRNCA for water budgets and groundwater modelling efforts; and
- determine the source of water (groundwater versus precipitation or runoff) consumed by key riparian plant species within the SPRNCA (also important for water budgets and groundwater modelling applications).

This project did not include the Mexican portion of the basin until 2003 when an attempt was made by the Partnership and a Mexican coalition of water managers, city officials and environmentalists to form an informal binational watershed alliance. However, local communities and states in the U.S. and Mexico cannot legally enter into formal binational agreements according to the U.S.-Mexico 1944 Treaty, and the Mexican National Water Commission, northwest sector, did not support this effort, so it fell by the wayside. Other efforts were made subsequently with colleagues at the College of Sonora and the University of Sonora to revive the effort, but local watershed management remained in limbo until a recent transition to municipal management. A Mexican watershed organization like the Partnership has yet to appear.

The actual water issues challenging both parts of the basin are mine-related pollution, surface diversions, and groundwater pumping in Mexico, and in Arizona, potential water-rights' claims by downstream users and increased groundwater use by communities near the conservation area (Jackson *et al*., 1987; Pool and Coes, 1999). In the U.S. portion, irrigated agriculture, cattle grazing, mining and recreation, formerly the predominant land uses, are being supplanted by urbanization and rural development. The Partnership has to reach safe yield by 2012, or Fort Huachuca, the, chief economic driver in the area, will be shut down. To meet this goal, the Partnership has developed a Water Management and Conservation Plan (http://www.usppartnership.com/documents.html#consplan). However, population projections for southeastern Arizona, with roughly a 50 percent increase anticipated from 2000 to 2030, will result in a major water use increase to support municipal and domestic needs. Vegetation also requires a large portion of the budget (evapotranspiration) (Goodrich *et al*., 2000b).

In northern Mexico the predicted decline in water availability may exacerbate increasing competition for water resources between such productive sectors as agriculture and industry and domestic consumption (Magaña and Conde, 2001: 1). Increased production of copper from

extensive ore reserves in Mexico will likely continue to limit groundwater availability for municipal and agricultural uses in that region and compromise water-conservation efforts.

In addition to the potential for water scarcity associated with human extraction and climate variability, groundwater and surface-water contamination also affect the quality of water supplies near the headwaters of the San Pedro River. Inadequate or nonexistent wastewater-treatment plants contribute to uncontrolled discharge of residual waters into the river. Unlined landfills introduce a variety of known and unknown substances that infiltrate into the aquifer. Moreover, the copper mines produce industrial waste that contaminates groundwater supplies via unlined and occasionally overflowing tailing dams (Moreno, 1991: 7; Jamail and Ullery, 1979: 37-45; Zavala, 1987: 5). With the approval of the municipalities of Cananea and Naco, Sonora, and the support of the IBWC and CILA, the University of Sonora's DICTUS and the ADEQ conducted water-quality tests of the San Pedro River in 1998. Initial results indicated the presence of raw sewage and mining by-products, including arsenic, near the headwaters of the San Pedro and in wells close to Cananea (Da Viana, 1998: 1; Kamp, 1999; Maest *et al*., 2003).

DISCUSSION: RESEARCHERS WORKING WITH BASIN STAKEHOLDERS TO ADDRESS THESE CHALLENGES

Before the Partnership began addressing the water issues almost 10 years ago, the Southwest Watershed Research Center of the U.S. Department of Agriculture-Agricultural Research Service had already been working in the basin to quantify, understand and model the effects of changing climate, land-use and management practices on the hydrologic cycle, soil-erosion processes and watershed resources (www.tucson.ars.ag.gov). Building on the experience of these previous interdisciplinary experiments, 65 scientists from a broad spectrum of disciplines met in Tucson, Arizona, in July 1995, to discuss plans for a new effort named SALSA (Semi-arid Land Surface Atmosphere Program) (Wallace, 1995). Their objective was "to understand, model and predict the consequences of natural and human-induced change on the basin-wide water balance and ecological complexity of semi-arid basins at event, seasonal, interannual and decadal time scales" (Brady *et al*., 2000: 17). The SALSA program was viewed as very successful scientifically (primary results summarized in Chehbouni *et al*., 2000) and in terms of bridging the gap between research scientists, watershed managers and decision-makers. This was exemplified by a binational conference, "Divided Waters–Common Ground" ("*Aguas Divididas–Áreas Comunes*") designed specifically to include basin residents and decision-makers. At this bilingual conference, both U.S. and Mexican scientists and residents listened to one another regarding needs – unlike more typical scientific meetings at which scientists talk to each other or "tell" basin residents what they did (Brady *et al*., 2000).In 2000 much of the SALSA research was incorporated into SAHRA, the NSF Science and Technology Center for Sustainability of semi-Arid Hydrology and Riparian Areas, based at the University of Arizona.

Since then SAHRA has been developing an integrated, multidisciplinary understanding of the hydrology of semiarid regions and building partnerships with a broad spectrum of stakeholders (public agencies and private organizations) so that this understanding is applied to optimal management of water resources and rational implementation of public policy. The key question for SAHRA is, "How can science help communities manage their water resources in a sustainable manner?" Shortly after this in 2001 the San Pedro Basin became an official HELP basin.

Within this context, the University of Arizona's Udall Center for Studies in Public Policy began working with the Upper San Pedro Partnership, HELP, and SAHRA in the Upper San Pedro River Basin to integrate scientific research with the needs of regional water-resources management organizations and policy-makers (Browning-Aiken *et al*., 2004). The Udall Center used stakeholder surveys and historic and socio-economic research to assess the effectiveness of current water-management organizations in addressing basin issues and to identify potential links between scientific research and stakeholder needs for more effective management tools. The Center also facilitated a series of binational meetings or dialogues for Arizona and Sonora basin stakeholders to discuss the potential development of a binational watershed alliance. Similarly, the Udall Center worked with CLIMAS (Climate Assessment of the Southwest) at the University of Arizona to characterize and analyze droughts as another means of addressing institutional, management and policy issues of binational concern. An integral part of this research was studying whether watershed councils are effective institutions for integrating scientific research on hydrology and ecosystems with watershed management at a binational level. The hypothesis was that decision-making for sustainable development of water resources is based on a full assessment and analysis of complex ecological and socio-economic relationships within a watershed, and availability of effective tools, such as decision-support system models.

As a HELP basin, researchers and decision-makers working together within the Partnership have designed and completed research that quantifies riparian water needs, characterized the basin hydrologically and socioeconomically, quantified basin recharge, built a state of the art Groundwater Model, and developed 50 water conservation and augmentation strategies, many currently being implemented by the Partnership (http://www.usppartnership.com/documents.html#consplan). Perhaps most importantly, the Partnership, SAHRA and Udall Center used their research to develop a complex decision support tool that enables water managers and other stakeholders to test alternative management strategies and select the ones that help the Partnership achieve its goals. The DSS model can be considered an environmental conflict mediation tool both for Arizona decision makers and between Arizona and Sonora decision-makers and stakeholders.

An additional tool outside of HELP which the Partnership hopes to implement with Mexico is basin twinning with the Maestos/Nestos transboundary basin in Greece/Bulgaria. The International Network of Basin Organizations (INBO) approved a proposal for a twin basin

exchange in which joint teams from Arizona/Mexico and Greece/Bulgaria would exchange week long visits for IWRM. The main objective of this mission is to transfer knowledge on the forming of bi-lateral agreements, and on how such agreements may be sustained in the long-term, with particular emphasis on identifying possible sources of conflict and environmental mediation processes that can diffuse tension and conflict. It is hoped that the Partnership will benefit from learning about the Mesta/Nestos River basin and seeing how bi-lateral cooperation in this basin works in practice and that the two teams will develop a set of recommendations for bi-lateral agreements on the San Pedro River Basin. However, even with funding, the Mexican participants have not yet signed the documents, which will expire at the end of 2007.

LESSONS LEARNED FROM THE SAN PEDRO HELP EXPERIENCE

- High stakeholder involvement increases the potential for success in any watershed, and has proven important within the Upper San Pedro River Basin (Born and Genskow, 2001; Browning-Aiken *et al*., 2004; Imperial and Henessey, 2000; Kenney and Lord, 1999; Leach, 2000; Schuett *et al*., 2001; Scurlock and Curtis, 2000; Vasquez-Castillo, 2001). Public dialogues within the two San Pedro watershed organizations, the Partnership and a Mexican NGO ARASA, have "stirred controversy and revealed the importance of accounting for the region's social and political forces" (Varady *et al.,* 2000: 234). Yet water law in Mexico has been slower than in the United States in encouraging grassroots stakeholder involvement; this makes sustaining local institutional parity and representation more challenging.
- Creating international law regarding transboundary aquifers remains the most difficult challenge for border water management, but specific basin efforts to remedy water quality problems might be the first step needed to branch into groundwater issues.
- The research scientists who are now working directly with water managers and decision-makers are more cognizant of applied-science needs, and are also being educated about the constraints and political realities under which managers and decision-makers operate.
- A "bottom-up," collaborative, community-based approach between stakeholder organizations and agencies and the scientific community can serve as a more effective management approach than the old top-down, regulatory models (Milich and Varady, 1999).
- National policy considerations influence the potential for coordinated basin management. Local initiatives along the northern Mexican border are linked to national policy demands. Mexican environmental policy frequently runs counter to Mexican economic policy in the critical importance attached to development, especially in mineral resources and *maquiladoras* along the northern border.
- The Arizona Groundwater Code's failure to include ecological protection as a beneficial use of water is an obstacle to surface water flows in the San Pedro River.
- Differences in Mexican and U.S. water law make it difficult for binational institutions to treat water as a common pool resource along the border.
- Building consensus and bringing a broad spectrum of groups and interests together to speak with "one voice" and share a common vision of success, as the Upper San Pedro Partnership does, is a very compelling strategy in acquiring financial and political support.
- Collaborative research based on water-stakeholders' needs is far more effective in addressing complex management of a basin, especially a binational one. These "place-based" issues force scientists from many disciplines to look at the same piece of ground, the same data and often, to work together in the same location.
- Finally, trust between scientists, managers, decision-makers, environmentalists, developers and the public is essential for integrated watershed management (Browning-Aiken *et al*., 2004). Building and holding this trust requires a major commitment of time and energy by all

involved. For research scientists, this long-term commitment to build trust with stakeholders runs counter to the time of a typical two- or three-year research grant.

CONCLUSION: CONTRIBUTIONS TO THE HELP AGENDA

As a HELP demonstration basin, the Upper San Pedro River Basin experiences indicate that the potential for successful planning and management efforts greatly increases with improved understanding of the impacts of climate variability, land-use changes and hydrologic processes. This information appears essential for decision-making, especially in a transboundary setting – which is almost more often the norm than the exception, as international basins cover 44 percent of the land surface of the earth (Varady and Morehouse, 2003). In this setting, with disparities between nations in economic development, infrastructure capacity and political orientation, the greater engagement of communities and stakeholders at the regional level in priority-setting for water-resources issues offers a glimmer of hope to water conflicts elsewhere. However, the effectiveness of local watershed councils is directly linked to utility and reality of water laws and to the availability of scientific information and cultural attitudes towards water. Access to data and effective decision-making tools have been regularly named as critical to building institutional capacity, but management decisions must reflect the attitudes, meanings and values attached to water and land use as well (Wolfe, 2002: 3-11). Likewise water laws suggest national or regional cultural values and the nature of stakeholder expectations as well as obligations.

The HELP agenda promotes the integration of climate variability, specifically understanding the region in terms of seasonal to interdecadal time scales and the causes of climate variability, into the management strategies of water stakeholders and managers. This is especially important because the basin is periodically subject to both drought and monsoonal flooding. The HELP approach can redirect government agencies at the federal, state and local level in terms of setting the agenda for sustainable use of water resources, so that issues of equitable access to water, the application and use of economics, and incentives for efficient use are addressed through public participation in decision-making. Water users need help from agencies in understanding how water budgets are constructed and in understanding their own role in capturing lower-cost opportunities for water savings.

Finally, the Upper San Pedro River 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, lawyers and policymakers.

In the Upper San Pedro River Basin, contemporary communication over the prospect of basin water management began with the Commission on Environmental Cooperation's report, *Ribbon of Life* (CEC, 1999), with the recommendation for the creation of a Coordinated Resource

Management Program. It is noteworthy, however, that the communication process was carried forward not by an exogenous multinational institution, but by a bottom-up federation of local residents, scientists, environmental organizations and educators, working with municipal, state and federal officials. They accomplished this through a series of collaborative projects including SALSA, the San Pedro Dialogue on Water and Climate, and the 1999 binational San Pedro Conference "Divided Waters–Common Ground" ("*Aguas Divididas–Areas Comunes*").

While the process of coordinating binational resource management is a slow one, residents, scientists and water managers have addressed issues in the Upper San Pedro River Basin with intensity if not enthusiasm. Collaborative, interdisciplinary research efforts, the binational forums for information exchange in the basin and the evolution of the Upper San Pedro Partnership, all suggest a momentum toward integrated, binational water-resources management.

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