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The Importance of Institutional Asymmetries to the Development of Binational Aquifer Assessment Programs: The Arizona-Sonora Experience

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Abstract: Setting water policy depends fundamentally on the location of the supply and demand for water and the legal/institutional framework for water management. Within and across nations, laws and structures for water management decision making vary, often significantly. Recognizing these differences can aid in overcoming challenges inherent to the assessment and management of transboundary waters. This paper examines current binational efforts to develop the scientific information to support water management decision making along the United States-Mexico border. The particular focus is on transboundary aquifers along the border shared by the states of Arizona in the United States and Sonora in Mexico. Legislation enacted in the United States (Public Law 109-448) established a governmental-academic partnership to assess transboundary aquifers. The paper discusses the establishment of a working partnership between Mexico and the United States, which led to an official binational cooperative framework for transboundary assessment. It explains how the extensive effort to recognize and accommodate asymmetries in the underlying legal and regulatory frameworks for water management was essential to meeting the objectives of both countries. The focus of the binational investigations is briefly discussed. The paper concludes by noting the opportunities for additional cross-border scientific and water management collaboration should funding and institutional commitments continue.

Keywords: transboundary aquifers; transboundary waters; water policy; institutional asymmetries; water management

1. Introduction and Objectives

Identifying and characterizing transboundary aquifers have been the focus of world-wide activity, which has been documented by UNESCO's Internationally Shared Aquifer Resources Management Programme (ISARM) [1] and the World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP) [2]. The International Hydrological Programme of UNESCO is a WHYMAP partner and was instrumental in contributing to the development of the draft articles on the Law of Transboundary Aquifers [3]. This far-reaching document establishes a framework that recognizes national sovereignty but emphasizes the need for binational/multinational management of aquifers that extend below two or more nations. It also underscores the importance of multilateral mechanisms for cooperation and the exchange of data and information. In particular, Article 7, Section 2, General Obligation to Cooperate, calls for the establishment of joint mechanisms of cooperation, whereas Article 8, Section 2 indicates the regular exchange of data and information. Moreover, it states: "Where knowledge about the nature and extent of a transboundary aquifer or aquifer system is inadequate, aquifer States...shall take such action individually or jointly and, where appropriate, together with or through international organizations."

In 2006, the United States (US) government took a step toward formally recognizing the importance of transboundary aquifer assessment at the US border with Mexico (MX) when it enacted Public Law 109-448, the United States-Mexico Transboundary Aquifer Assessment Act (Act) [4]. The purpose of this Act is to "establish a United States-Mexico transboundary aquifer assessment program (TAAP) to systematically assess priority transboundary aquifers." It "authorize[s] the Secretary of the Interior [through the United States Geological Survey] to cooperate with the States on the border with Mexico and other appropriate entities in conducting a hydrogeologic characterization, mapping, and modeling program for priority transboundary aquifers, and for other purposes." An aquifer is defined to be a "subsurface water-bearing geologic formation from which significant quantities of water may be extracted". The Act further defines a transboundary priority aquifer as "a transboundary aquifer that has been designated for study and analysis under the program." The Act specified certain priority aquifers as initial focal points for the TAAP. Issues to consider when specifying additional transboundary aquifers are (1) the proximity to areas of high population density; (2) the extent of aquifer utilization; and (3) the susceptibility of a transboundary aquifer to contamination. Figure 1 shows the border states in the US and MX participating in the TAAP. They include the Arizona, New Mexico and Texas in the United States and Chihuahua and Sonora in Mexico.

Figure 1. Map of the states participating in the US-Mexico Transboundary Aquifer Assessment Program (TAAP).



The US state of Arizona shares its southern border with the Mexican state of Sonora. For the Arizona-Sonora border region, the Act specifies the Santa Cruz and San Pedro aquifers as the priority aquifers. Figure 2 shows the location in the states of the Arizona-Sonora priority aquifers, which are the focus of this paper, and Figure 3 shows these two aquifers in greater detail. The Santa Cruz aquifer region is home to the upper reach of the Santa Cruz River, which has the interesting feature of starting in Arizona, flowing south into Mexico, only to turn back and flow north into Arizona. The San Pedro River starts in Cananea, Sonora, Mexico, home to a large copper mining operation, and flows north into Arizona and through the Sierra Vista area in Southeastern Arizona. The Sierra Vista area is home to the Fort Huachuca US army base, a growing population, and a national conservation area known as the San Pedro Riparian National Conservation Area.

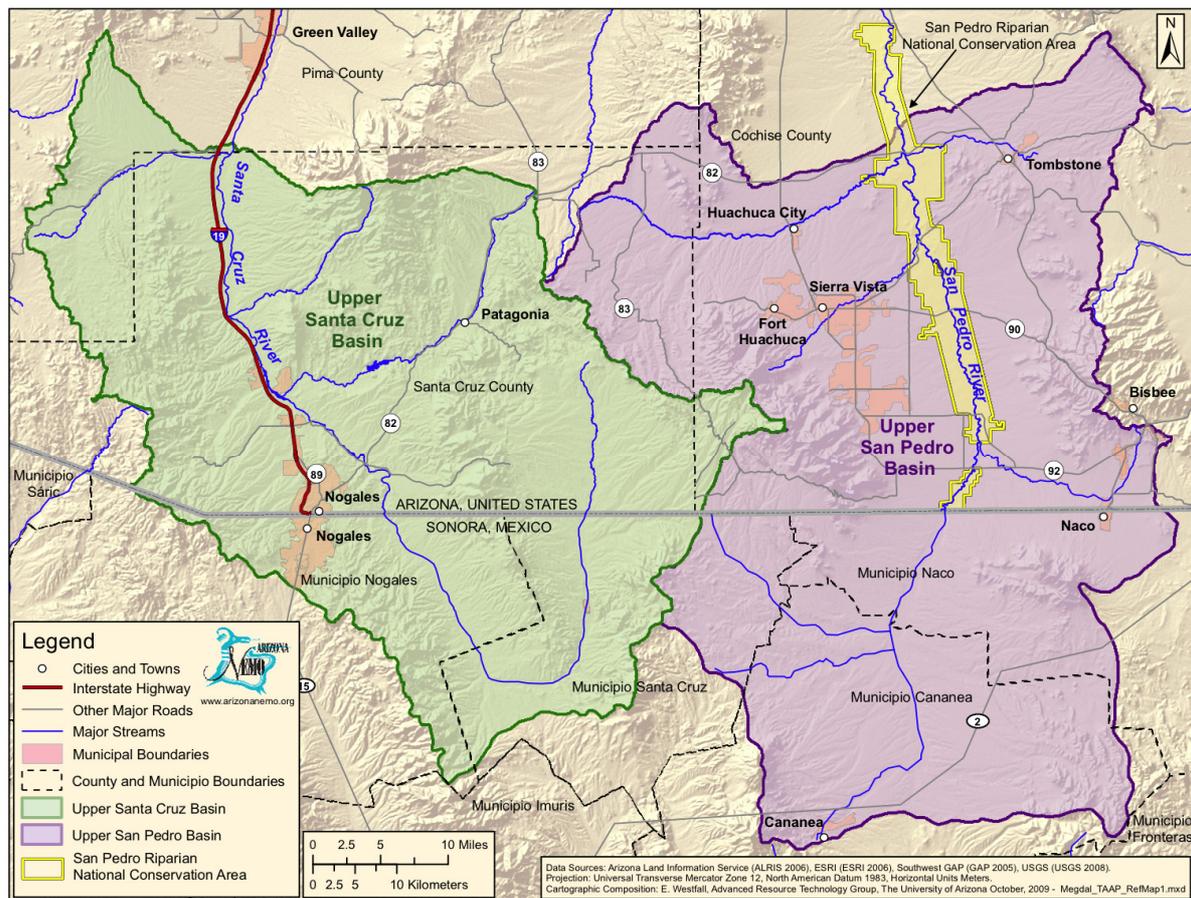
The objective of this paper is to provide understanding of the challenges, effectiveness, and factors contributing to successful binational aquifer assessment. This is important as the challenges and key water policy drivers [5] addressed by the United States-Mexico Transboundary Aquifer Assessment Program can offer generic lessons for other transboundary contexts. In particular, we address institutional asymmetries and how these were overcome in order to establish collaborative efforts for the acquisition and sharing of hydrologic data and information, leading to further socioeconomic and institutional studies that are central to water policy. Policy can be defined as “a definite course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future decisions [6].” Water policy depends on several factors, including the following: resource availability; location and timing of water demands and supplies; economics;

historic and current legal/institutional framework, including the extent of centralized *versus* decentralized decision making; the nature of involvement of multiple governmental and non-governmental entities; politics; public values; and information [7]. After discussing the geographic context for Arizona-Sonora transboundary aquifer assessment, the institutional framework of laws and participating government agencies is addressed. The challenges associated with asymmetries in these legal frameworks are explained. The relevance of the experience gained through implementation of the Arizona-Sonora transboundary aquifer assessment work to accomplish Articles 7 and 8 of the proposed Law of Transboundary Aquifers and transboundary groundwater management is discussed in the concluding section.

Figure 2. Map showing the general location of the Arizona-Sonora Transboundary Aquifers.



Figure 3. Enlarged map depicting the Arizona-Sonora Transboundary Aquifers TAAP: Santa Cruz Aquifer on the left; San Pedro Aquifer on the right.



2. The Geographic Context for Arizona-Sonora Transboundary Aquifer Assessment

Any effort to understand water policy will necessarily be predicated on the location of water supplies and demands. Aquifer stress or vulnerability will depend most importantly on pumping relative to recharge and water quality. As explained in the introduction, priority transboundary aquifers under the TAAP are those that are used to a significant extent to serve population and economic centers and may be vulnerable to water quality risks. The Arizona-Sonora priority aquifers indeed support human populations and economic activities ranging from mining, agriculture and ranching, manufacturing and tourism. Vulnerabilities are not limited to water quality. Precipitation events are highly variable, with both flooding and unpredictably long dry periods affecting both aquifer utilization and recharge rates [8].

The Santa Cruz aquifer supports significant manufacturing, agricultural and ranching activity. The Nogales border is a major crossing point for produce entering the United States from Mexico. The communities of Nogales, Arizona, and Nogales, Sonora are in close proximity, with both abutting the international border. They depend on groundwater for their water needs and share an international treatment plant, which is located in the United States and operated by the International Boundary and Water Commission (IBWC). Over two-thirds of the waste flow treated at the plant emanates in Mexico. Discharges of the treated wastewater or effluent flow north from the treatment plant and

support many miles of riparian growth. Except for portions affected by the regular effluent flow, the Santa Cruz River is ephemeral, with intermittent flows, including high volume flood flows, related to precipitation events.

Arizona is among the fastest growing of US states. The population is mostly urban-based. Mirroring the growth trends on the US side of the border, Mexican border states and cities continue to experience growth in population and economic activity that outpaces the national average. Border sister cities have populations on the Mexican side that can be as high as ten times greater than on the US side [9]. For example, the twin cities of Nogales, Arizona, and Nogales, Sonora, have current populations of approximately 50,000 and 300,000 inhabitants, respectively. Nogales, Arizona is growing at 1.3% per year and is projected to continue growing into the next century. Nogales, Sonora is growing more rapidly at 1.6% per year. Both are projected to stabilize, although over different timeframes [10].

The San Pedro aquifer supports communities in Sonora and Arizona that are not adjacent to the border. The economic activity of Cananea, Sonora, with a population of approximately 40,000, is dominated by copper mining. The region relies on groundwater for its water needs. On the US side, Sierra Vista is the largest of several communities relying on the San Pedro Aquifer. The economy is dominated by activities related to the civilian and military workers of Fort Huachuca, with ecotourism also being an important component of the region's identity. The flows of the San Pedro River are ephemeral, except for the perennial reach that flows through the San Pedro Riparian National Conservation Area (SPRNCA). Maintaining this perennial flow is a priority of the Upper San Pedro Partnership (USPP), a non-governmental association of agencies, local governments and environmental organizations dedicated to the health of the aquifer and river. Its goal is to "coordinate and cooperate in the identification, prioritization and implementation of comprehensive policies and projects to assist in meeting water needs in the Sierra Vista Subwatershed of the Upper San Pedro River Basin [11]." Maintaining San Pedro River flows through its perennial reach is also a priority of the United States government, which has mandated that the USPP develop and implement a program for sustainable water use for the region:

The Defense Authorization Act of 2004, Public Law 108–136, Section 321, stipulates the way in which Section 7 of the Endangered Species Act applies to the Fort Huachuca, Arizona military reservation. Section 321 of this Act further directs the Secretary of the Interior to prepare reports to Congress on steps to be taken to reduce the overdraft and restore the sustainable yield of ground water in the Sierra Vista Subwatershed [12].

Mexican authorities initiated the formation of a watershed commission (*comisión de cuenca*) for the San Pedro, which by institutional design was intended to include cross-border stakeholders from the US. For a variety of reasons, chiefly due to internal staff transfers within Mexico and a labor strike at the Cananea mine that raised political sensitivities on a range of issues, the watershed process has stalled; however, authorities continue to voice optimism, which at least indicates the process has not been dropped altogether.

The Colorado River is a third transboundary river in Arizona that, with its associated groundwater, flows from north to south. This region, along with the border area shared by the states of California in the US and Baja California in Mexico, however, was not included in the Act. This is because legal matters related to the lining of the All American Canal, which is located in California, were pending

during 2006, when the Act was being considered by the U.S. Congress. California opted out of participation in the TAAP. In addition, due to the many national level and international complexities associated with management of the Colorado River, transboundary assessment of groundwater associated with the Colorado River was excluded from the TAAP. Because the outcomes regarding California-Baja California border and the Colorado River-related aquifers were the result of private negotiations rather than formal congressional hearings, this information is not documented in official sources. Paper co-author Sharon Megdal was the only non-federal person providing testimony at the May 2006 subcommittee hearing on the bill containing the Act (S.214 and H.R.469). After the hearing, she was occasionally consulted as modifications to the bill's language were developed.

3. The Institutional Context for Arizona-Sonora Transboundary Aquifer Assessment

The legal framework for water management is quite different in the United States and Arizona from that of Mexico and Sonora, leading to important differences in the responsibilities of federal and state agencies. These differences, or asymmetries, in turn affect implementation of a transboundary aquifer assessment program. Most notably, water management, including processes for granting and monitoring water rights is centralized with the federal government in Mexico, where the US approach is highly decentralized [13]. In the US, water management is largely handled at the state and/or sub-state level, although the federal government establishes regulations related to the drinking water quality as well as the quality of water discharged into waters of the United States. The approach to water right permitting and water use monitoring, on the other hand, varies by state and sometimes within states. Within-state variation is indeed the case for Arizona, where we see different water management regimes in effect for the Santa Cruz and San Pedro aquifers. While a full explanation of water management in Arizona is beyond the scope of this paper [14,15], some discussion is warranted because the differences in water management approaches in the two regions are reflected not only by the water-use regulations but also by governmental involvement.

In Arizona, surface water and groundwater are considered distinct water bodies and regulated in distinct manners. In neither case is there a private property right conveying ownership of the water molecules themselves. Surface water is appropriated on a first-in-time, first-in-right basis, whereas groundwater use is predicated on beneficial use and subject to permitting in parts of Arizona known as Active Management Areas (AMAs). The Arizona portion of the Santa Cruz transboundary aquifer falls within the Santa Cruz AMA, for which the state-level Arizona Department of Water Resources (ADWR) has regulatory oversight. Groundwater use regulations in an AMA, which apply to the municipal, industrial and agricultural sectors, include permitting for wells greater than a certain size, state-approved conservation programs, and compliance with an assured water supply program governing municipal growth. The assured water supply program requires those developing properties to establish 100 years of physically, legally and continuously available water. Importantly, the AMA status includes a state water management goal, which for the Santa Cruz AMA is maintain "safe-yield" (the long-term balance between the annual amount of groundwater withdrawn in the AMA and the annual amount of natural and artificial recharge) while also preventing local water tables from experiencing long-term declines. This goal, which recognizes the unique character of the groundwater basins and their dependence of surface water flows, is unique among the five AMAs. Groundwater

models and other regional analyses have been developed, but they do not include areas in Mexico. From 1994, when the Santa Cruz AMA was authorized by state law, until July 2010 ADWR personnel were located in Nogales, Arizona. Due to state budget constraints, the local office was closed. While formerly employed personnel still live in the region, ADWR no longer has a regular staff presence.

The Arizona portion of the San Pedro aquifer is not in an AMA, although there are groundwater use concerns in this region, particularly as they relate to flows of the San Pedro River. Hence, there are no state-mandated conservation programs for this region, nor an assured water supply program. At the sub-state level, however, the Cochise County government has established some zoning regulations related to water use in the Sierra Vista region and does consider the adequacy of water supplies when approving certain types of land uses. Although not an AMA, the region's groundwater has been modeled extensively by the US Geological Survey (USGS) and other analyses of water supply and conservation potential have been conducted. Due to the importance of Fort Huachuca and the SPRNCA, significant federal dollars have been allocated to understanding the groundwater and surface water conditions in the region. In addition, the state authorized the region to consider via a public vote, the formation of a regional water management district. The formation of the district, however, was defeated in November 2010, meaning that the region operates with very limited governmental oversight of groundwater use. ADWR personnel have not been located in the Sierra Vista region, although they have participated in the USPP and been involved in numerous studies. Most notable among them is the 2005 "Upper San Pedro Review Active Management Area Report," which formed the basis of the ADWR Director's decision not to establish this region as an AMA. Groundwater overdraft was deemed insufficient to warrant formation of an AMA in this region [16].

Against this institutional backdrop, the US-Mexico Transboundary Aquifer Assessment Program was established by the United States Congress as a partnership between the United States Geological Survey (USGS) and the federally recognized water resources research centers in each of the US states participating in the TAAP. By law, funding authorized by the US Congress would be split equally between the USGS and participating universities, although the Act did not specify a formula for distributing funds across the participating US states. The university research centers were authorized to contract with entities in the US and Mexico, with the additional requirement that any funds expended in Mexico would have to be matched dollar-for-dollar, although the match could be in-kind rather than cash. The TAAP was authorized for 10 years, with a funding authorization of \$50 million.

Funding authorization does not mean that funding is in fact approved and available; instead the annual federal budget approval process determines the funding. Although approved in late 2006, TAAP funding has never been included in the budget submitted by the US President to the Congress. The President's proposed budget reflects the request of the Executive branch of the US government, and the USGS of the Department of the Interior is part of the Executive branch. As such, it cannot lobby for changes in the budget once the President's budget is submitted. To date, the university partners have been successful in obtaining congressional support for a total of \$2 million in programmatic funding. One third of that funding, approximately \$667,000, has supported the USGS and university-led component of the Arizona-Sonora portion of the TAAP. There are no funding requests for TAAP in either President Obama's Fiscal Year 2011 or Fiscal Year 2012 budgets. More will be said on the funding situation in a later section of this paper.

In formulating the Act and specifying its priority aquifers, however, there was no direct consultation with the TAAP's partner country, Mexico. Nor was there any consultation with the US section of the binational International Boundary and Water Commission (IBWC), the organization whose mission is "to provide binational solutions to issues that arise during the application of United States-Mexico treaties regarding boundary demarcation, national ownership of waters, sanitation, water quality, and flood control in the border region" [17]. Instead, the Act instructs the implementers of the TAAP to consult with IBWC "as appropriate". While this might be cited as an oversight of the IBWC, which has sections in the US and Mexico that are considered diplomatic agencies, there is no treaty addressing ownership of groundwater in the border region, nor is there any support for formal IBWC involvement in US groundwater management [18].

In Mexico, water management is centralized with the federal government [5,19]. CONAGUA, part of the Ministry of the Environment and Natural Resources, holds water allocation and policy priority over the state water agencies and municipal water utilities. It also is involved in funding, conducting and coordinating water-related research throughout the country. The Mexican section of the IBWC, the Comisión Internacional de Límites y Aguas (CILA), is involved in all transboundary water matters at the border between Mexico and the US, whether they be surface water or groundwater related. CILA is involved in all water matters that affect Mexico's border with the US and has established diplomatic protocols with the US Section.

Regardless of the lack of consultation in the formulation of the US legislation, these asymmetries had to be addressed promptly in order to carry out a truly binational aquifer assessment effort.

4. Development of a Binational Cooperative Framework and Aquifer Assessment Program

Approval of the US-Mexico Transboundary Aquifer Assessment Act directed the establishment of a formal program of transboundary aquifer assessment. Although there were ongoing assessment efforts in both the Santa Cruz and San Pedro aquifers and on both sides of the border, these efforts were not coordinated. Even before funding became available to the US participants, the stakeholders began to meet. Meetings started in the summer of 2007, although US funding for the program did not flow to USGS or the University of Arizona until early 2008.

After initial meetings involving only US participants, meetings were expanded to include representatives from both sides of the borders. These efforts, which included technical meetings, site visits, conference and other stakeholder presentations were designed to do one or more of the following: (1) share information the status of the data and modeling; (2) visit sites to understand the physical and other characteristics of the aquifer regions; (3) develop the relationships and communication channels important for TAAP implementation; and (4) disseminate information about the TAAP purpose and progress in order to build support for and understanding of the TAAP. In December 2008, the Arizona-Sonora portion of the TAAP was accepted as a case study by ISARM and a short description of the aquifers was included on the WHYMAP, 2009 edition. The TAAP has been supported by the binational Water Committee of the Arizona-Sonora Commission, and it has been the subject of international and binational meetings and conferences. Outreach activities that share the lessons learned through the early years of this program are helpful to those involved in promoting the importance of transboundary aquifer assessment throughout the world.

Three requirements to establishing a program of binational aquifer assessment emerged. First, a framework for cooperation and collaboration agreeable to both countries had to be developed, with the framework serving as the vehicle for agreement on aquifers subject to joint investigation. Second, an agreed upon set of assessment activities had to be established. Finally, in order to carry out jointly scoped and jointly funded projects in Mexico, a joint funding arrangement had to be developed that met the requirements of both nations.

The first requirement involved in-depth negotiations and discussion over a period of time. Because Mexico required that binational collaboration flow through CILA, its section of the International Boundary and Water Commission, the US Section emerged as a key player in this effort. From the US perspective, the significant asymmetries in the roles of the two sections of IBWC presented itself as a fundamental challenge in that the Act did not give IBWC the responsibility for carrying out the intent of the legislation. That role was given to the USGS, the science arm of the US Department of the Interior and an agency well respected for its hydrologic knowledge and studies. Rather than being consulted “as needed,” US IBWC involvement became essential. Nevertheless, negotiations involving both sections of IBWC, other federal-agency representatives from both sides of the border, and university representatives from Arizona, Texas and New Mexico were successful. Co-author Scott was a core participant in all these negotiations; bilingual fluency was essential to the formulation of specific wording that allowed the agreement to be accepted by both Mexico and the US. On August 19, 2009, a Joint Cooperative Process was signed by the Principal Engineers for the US and Mexican sections of the IBWC [20].

A framework was thereby established to assure concurrence of the US and Mexico for binational aquifer assessment activities, facilitate agreement on the aquifers that will be evaluated jointly, and establish and coordinate binational technical advisory committees for each aquifer. In addition, the IBWC would serve as the official repository for binational studies. It was agreed that each country would be responsible for studies conducted within its boundaries, with the possibility for sharing expenses if agreed upon through an IBWC-established funding arrangement. Mexico soon thereafter agreed that the Santa Cruz and San Pedro were aquifers subject to binational study.

A binational TAAP workshop hosted by the University of Arizona was convened in November 2009 to develop a binational work plan for the two Arizona-Sonora aquifers. Although funding was highly uncertain, it was important to TAAP progress that stakeholders gather to guide TAAP activities and provide information on what could be accomplished under different funding scenarios and time frames [21]. The workshop, coupled with the approval of the Joint Cooperative Process, led to the establishment of a binational technical advisory committee that would oversee work for both the Santa Cruz and San Pedro aquifers. This committee then identified the opportunity to conduct work in Sonora through the TAAP, which would be binationally funded. In keeping with the Act’s requirements, CONAGUA agreed to match US funding on a dollar for dollar basis with a total of \$160,000 (approximately two million pesos) in cash funding provided to Mexican experts to conduct binationally-prioritized studies for the two aquifers.

The flow of TAAP funds is somewhat complicated and requires explanation. It relates to provisions of the Act as well as IBWC’s desires regarding its role in funding joint work. As noted, 50 percent of the funds appropriated by Congress stay with USGS to fund their efforts related to the TAAP. The other 50 percent flows to the participating universities through the USGS. It is not a direct pass-through,

however. Each university must submit a proposal to the USGS with a budget and narrative specifying the tasks and details for spending the funds. Upon approval, the USGS approves funding for each university. The university partner, in this case, the Water Resources Research Center at the University of Arizona, is able to use these funds (subject to approval, of course) to fund work by outside entities, including work in Mexico. In 2010, through discussions of the joint technical advisory committee, it was agreed that US funds would be used to fund water balance work for both aquifers in Sonora, with the goal being to collect some important baseline information needed for later binational modeling.

IBWC required that the funds to Mexico flow from the University of Arizona to the US section of IBWC, who would then send the funds to the Mexican section. It would be the Mexican section that would be responsible for administering the contract with the university researchers in Sonora. Rather than engage in a direct funding agreement with the University of Sonora, which would not be expected to be difficult to accomplish, the University of Arizona had to develop an agreement with the US Section of the IBWC. Again, asymmetries in institutional requirements became paramount. Each party to this agreement had quite different rules and regulations that govern its contracting. The University of Arizona required sufficient review authority in order to determine that payments were appropriate, but it would not have official contract oversight responsibilities. At times it seemed like it would be difficult to overcome these administrative obstacles to what seemed like an overly circuitous route to funding binational work. Yet hard work on the part of the university contracting officers and the IBWC were successful and the agreements are in place for binational assessment activities.

The Arizona-Sonora binational assessment focuses on aquifer modeling and technical studies of water availability, supply, and use. Two additional aspects—water quality and aquifer management—that were raised and discussed at the November 2009 priority-setting workshop were agreed to be studied at a later time, funds permitting. The fact that water availability was prioritized as the single most important assessment activity underscores the importance of groundwater to meet human needs in the Arizona-Sonora border region.

5. Additional Considerations Related to Budgetary Matters, Stakeholder Engagement and Information Sharing

The TAAP was authorized as a 10 year program with expenditures up to \$50 million. About half way through the 10-year period, only \$2 million has been spent. In the early years, significant funding was not required. Time was spent developing an inventory of existing studies for the aquifers [22] and developing the relationships and cooperative frameworks required to carry out this new program. Site visits were conducted. Information sharing has been critical to this program, with numerous major presentations and papers presented and/or prepared by TAAP team members. In addition, the University of Arizona team has compiled two-page facts sheets in English and Spanish, which are regularly updated and posted on the TAAP web site [23]. These concise fact sheets have been very useful when explaining the program to public officials, regional stakeholders, and other interested parties.

Having developed a strong foundation built on trust, cooperation and commitment to a binational work program, the partners are poised to undertake additional binational assessment activities, particularly joint modeling of the aquifers. Growth, flooding and climate variability will affect the conditions of the Santa Cruz and San Pedro aquifers. Significant uncertainty surrounds the timing and

extent of both natural and human-caused impacts to the aquifers. Joint modeling and scenario analyses are necessary for understanding the status of and vulnerabilities to the Santa Cruz and San Pedro aquifers. Having worked through the many institutional issues, including those related to institutional asymmetries, the work can progress if there is multi-year commitment to funding the necessary assessment activities.

6. Concluding Remarks—Relevance for Transboundary Aquifer Assessment and the Law of Transboundary Aquifers

This paper has focused on the institutional challenges associated with implementing binational aquifer assessment. While the particulars pertain to the Arizona-Sonora portion of the United States-Mexico Transboundary Aquifer Assessment Program, the basic issues would be expected to exist in other settings. It is important for those involved in these challenging efforts share their experiences and lessons learned in order to foster understanding of the complexities and challenges involved. Transboundary aquifer assessment efforts involving two sovereign nations require time, patience, and the commitment of human and financial resources.

The United States, by federal law, established TAAP as a partnership between a federal agency, the USGS, and public universities at which federally-recognized water research centers were located. The authors argue that this type of partnership has been effective and suggest others look to it as a model. Transforming a binational program that was originally authorized by a single country has required building a partnership that recognizes and respects the legal and institutional/policy frameworks of both countries. Development of the joint cooperative process, along with conducting a workshop, was an essential step along the way to acceptance and implementation of the work plan.

The work of the Arizona-Sonora portion of the TAAP is in keeping with the actions envisioned by the Law of Transboundary Aquifers. As called for in Article 7, Section 2, the TAAP has established a joint mechanism of cooperation. Consistent with Article 8, Section 2, the regular exchange of data and information has begun. The participants have pursued actions, both individually and jointly, to fill gaps in information. Whether or not the voluntary joint management envisioned by the Law of Transboundary Aquifers follows, water managers, land use decision makers and water users require improved knowledge of the aquifer conditions.

Over a three-year period, the Mexican and US parties have addressed institutional asymmetries and established the foundation for genuinely collaborative efforts to acquire, share and analyze data/information. In addition to developing jointly accepted data for both sides of the border, existing and newly acquired data are currently being analyzed. Further hydrological assessment of the functioning and the state of the aquifers will be undertaken through the development of a unified conceptual model that incorporates new data. Hydrologists on the binational team are planning to formulate, parameterize, and verify a single hydrological model that will consider both quality and quantity. Cross-border socioeconomic and institutional studies are also envisioned as part of a long-term binational effort. These studies will address research questions centered on the drivers of water policy, the role of information to improve decision making (in particular, drawing on the hydrological studies), and cooperative binational mechanisms that enhance societal and environmental outcomes of

transboundary aquifer assessment. Future funding will determine whether the assessments needed for water policy decision makers will indeed continue.

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