A FRAMEWORK FOR THE NEGOTIATED SETTLEMENT OF INDIAN WATER RIGHTS CONFLICTS

by

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DEDICATION

This thesis is dedicated to Ramona and Rosalie, my grandmothers.

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ABSTRACT

Indian water users are claiming significant amounts of water throughout the western U.S.--water which non-Indians are using. Conflicts arise because there simply is not enough water to satisfy all claims to water. However, the negotiated settlement of these conflicts is becoming an accepted method of resolution.

The purpose of this study was to develop and illustrate a methodology to facilitate the negotiation process and aid disputants in reaching a solution. A framework was developed using elements of game theory. The creation and evaluation of negotiation resolution scenarios was illustrated. Through the application of the developed framework to an ongoing dispute, the existence of acceptable negotiation scenarios was demonstrated.

CHAPTER 1

INTRODUCTION

1.1 Problem Statement

The word commonly associated with water in the western United States is "conflict"--there simply is not enough water to satisfy all the demands and claims made by water users. This does not imply, however, that no attempts have been made at resolving these conflicts, nor that there is no hope for resolutions. Conflicts involving Indian water rights are a subset of the issues about western water facing decision makers, and recent developments can provide some insight on potential means of resolution.

To illustrate, through the assertion of their water rights, Indian water users have the potential to claim significant amounts of water throughout the West. In Arizona alone, Indian awards and claims to water amount to 69% of the total water resources of the state (Office of the Special Master, June 1995; Eden and Wallace, 1992). Meanwhile, the West has developed on non-Indian uses of the same water. While Indian claims have been more forcefully asserted in courts recently, non-Indian uses continue to become increasingly more dependent upon that water. There is the potential for a major shift in the control of water (therefore, power) from traditional managers (non-Indians) to new ones (Indians).

The traditional solution to water scarcity has been supply augmentation (i.e., dams, canals, and irrigation projects). When such measures are not adequate, particularly during times of drought, conflicts are resolved through non-physical means such as legal adjudicatory proceedings based upon the doctrine of prior appropriation where conflicts are resolved based upon use priority. Neither solution alone has been sufficient to resolve Indian water rights conflicts. The federal government, the principal financier, builder and operator of water projects, is becoming less willing and able to support these projects. There is less "augmentable" water. And, Indian rights to water are, themselves, in dispute. Adjudicatory settlements, in which the court determines only the right to water, can be costly, time-consuming, and due to reliance upon legal precedent, unrealistically inflexible or slow in responding to changing social, political, economic, even scientific realities.

However, the negotiated settlement of Indian water rights conflicts, where disputants jointly agree upon the terms of a solution, is becoming an accepted method of resolving these conflicts in the West. The cost and uncertainty of traditional solutions have resulted in the examination of negotiated settlements where there is a perception, at least, that participants might be better able to control outcomes and do so more inexpensively.

1.2 Objectives and Approach

The main objective of this study is to develop and demonstrate a framework to generate information that will facilitate negotiation as a process to resolve Indian water rights conflicts. A successful negotiation process is one in which all participants are voluntarily involved, where all participants have agreed upon the terms of the settlement, and one in which the agreed-upon settlement can be implemented. This study will examine that process. The development of possible negotiation scenarios will be discussed with the intent to develop resolution options that would be better for all disputants than would the likely outcomes of an adjudication alternative. This information will provide the basis to answer the question of whether or not to negotiate.

A secondary objective of this study is to assess the effect of uncertainty and new or changing information on the resolution of the conflict. Development of a defined framework will allow this examination.

To accomplish the objectives of this study, hydrologic, economic, and behavioral models are linked, because these aspects of the conflict are linked in reality. The physical setting is represented by a hydrologic model. Model results are transformed by a valuation procedure into attributes meaningful to the participants in the conflict. Each participant will be modeled as a multiple objective decision maker. A mathematical model of interdependent decision making (game theory) will be used to enable the projection of likely outcomes of the collective choice of the individual participants. Information regarding the General Adjudication of the Gila River and Its Sources, and the San Pedro River Basin within it, will provide case study inputs to the developed framework.

The emphasis of the study is development of a methodology. While realistic values were gathered and incorporated where necessary, they are not central to the focus of this study. Moreover, accounting for the attendant uncertainty was an element in the framework design. A preliminary examination of the effect of these values, as well as an examination of the rigor and flexibility of the developed framework, is also undertaken.

1.3 Benefits

Adjudicatory settlements are likely to be costly, time-consuming, and unpredictable for contending parties. Negotiated settlements offer the possibility of arriving at solutions acceptable to all parties at lower costs in both time and money. Negotiated settlements can allow for creative and versatile solutions to conflicts. Participant-generated negotiated settlements also allow for a solution that the participants themselves deem fair and equitable. The discovery of a set of possible negotiated solutions in the case study should be beneficial to the successful resolution of the conflict.

Indian water rights conflicts are complex and multifaceted. Organizing the known hydrologic, legal and economic information can aid in discovering critical data gaps. Organization of the data can lead to better understanding of the conflict and, hopefully, to realistic solutions.

1.4 Structure of the Thesis

The following chapter provides the historic and legal basis of Indian water rights conflicts, and a discussion of negotiated settlement of these conflicts. Chapter 3 contains a description of the case study area and describes the multiple uses of water within the San Pedro Basin. In Chapter 4, the concepts and methodology used in the development of the framework will be presented. In Chapter 5, the case study information will be applied to the framework and initial results presented. Analysis of the results will be presented in Chapter 6. A summary of the research, conclusions, and recommendations for future study will be presented in Chapter 7.

It is important to note that use of the term "Indian" throughout this study is in no way meant to imply ignorance of the controversy surrounding use of the term. The greatest respect is given to a people striving to maintain their identity despite the cultural challenges they've faced in the past 200 years. However, the term will be used throughout this study to maintain consistency with the literature by both Indians and non-Indians alike who show great sensitivity and understanding of the cultural aspects of the conflict.

CHAPTER 2

BACKGROUND

2.1 Water Law

Understanding the nature of water rights in the West is central to understanding the conflict regarding Indian water rights. In this chapter, a brief description of Western water rights and Indian water rights is presented. Past attempts at water rights conflict resolutions through negotiations will be examined. Additionally, federal activity in the West will be discussed. Understanding Indian water rights and the attendant conflicts involves understanding federal activity because the federal government, Indians, non-Indians, and the development of the West are inextricably linked.

2.1.1 Western Water Law

With the establishment of the 13 British colonies in America, came the English common (court-made) law notion that water use was dependent upon property ownership. A landowner had a right to use, but not diminish, the flow of water adjacent to his property--hence, the term "riparian" water rights or doctrine. When power and livelihoods were dependent on unimpeded flows, as with water mills, for example, riparian water rights were logical in a water-rich environment. The riparian right was accepted throughout the eastern United States. When populations began to move west, the obvious aridity and rare flowing water made application of riparian rights, in all but a few cases, unrealistic.

Most water rights in the West were generally obtained under the legal doctrine of "prior appropriation", an approach to the use of a scarce resource in an arid environment. Following the discovery of gold in California in 1848, water use conflicts began to arise among miners, especially placer miners, who required large amounts of water. Growing human populations and agricultural production increased the demand for limited water resources. Emerging from the customs and rules established at mining camps, the doctrine of prior appropriation was eventually adopted throughout most of the West as the basis with which to govern water allocation.

According to the doctrine of prior appropriation, a right to use water is established by the diversion of water from a natural water body and by application of that water to a beneficial use. Such a right is then superior to all subsequent rights in the event of scarcity.

There are several elements to prior appropriation (Getches, 1984; Sax and Abrams, 1986). First, the right is not determined by land ownership, as are riparian rights, but by use. Second, water must be diverted from its natural course. Third, the diverted water must be put to a beneficial use. The term "beneficial use" is subject to diverse interpretation; however, the beneficial use requirement was intended to prevent waste and to ensure that water could not be appropriated simply to keep others from having it (hoarding). Beneficial use is the measure of the amount of the water right and, once put to a use considered beneficial, the right is perfected. Fourth, if not used, the water right can be forfeited. Fifth (and significant to groundwater use), only water in "natural streams" is appropriable; in some states, groundwater use continues to be a right originating in ownership of the overlying land, following the riparian doctrine. A sixth element critical to the prior appropriation doctrine is seniority. The priority of a water right is determined by the date when water is first put to use, when work leading to application of use begins, or when notice to use is posted. A senior right is superior to all junior rights. During times of reduced flow, junior appropriators must reduce, even terminate, their water use, however severe the consequences. A junior right may be fulfilled only after senior rights are fulfilled completely and additional water remains. Hence, the prior appropriation doctrine is popularly summarized as "first in time, first in right."

Nine western states--Alaska, Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming--have adopted the prior appropriation doctrine as the primary means of water allocation, and have formalized it in state codes and/or administrative procedures (Getches, 1984). The prior appropriation doctrine also provides the initial and basic means to resolve conflicts over water. Water right adjudication, the legal determination of the type, amount, and priority date of water rights, is the primary means of removing uncertainties regarding appropriative water rights. An adjudication of water rights could result from one claimant seeking to clarify his right, clarification among several claimants, or as a result of statutory procedures. Adjudication by a state agency or court evolved from a desire to achieve a workable, quick and (importantly) comprehensive determination of rights on a river system, and to perpetuate the rights in public record (Hutchins, 1974).

2.1.2 Indian and Federal Reserved Rights

While a system of water rights has developed at the state level based upon the doctrine of prior appropriation, a separate and different system of water rights developed with respect to federal lands. Federal reserved water rights developed less from experience, as with the prior appropriation doctrine, than from decisions of the federal judiciary which, according to Burton (1991) is "...the governmental institution ostensibly least susceptible to shifting political currents and most sensitive to the honoring of governmental obligations." A complete review of all pertinent law and activities at both federal and state levels defining these rights is tortuous and fraught with ambiguity and contradictions. The following discussion is a review of salient features of court decisions generally regarded as central to formulating Indian water rights. The central theme of this discussion, however, was well-stated by the National Water Commission: "In the history of the United States Government's treatment of Indian tribes, its failure to protect Indian water rights for use on the Reservations it set aside for them is one of the sorrier chapters" (National Water Commission, 1973).

Nearly all the land constituting the West was acquired by the federal government through purchase or treaty, i.e. the Louisiana Purchase, the Gadsen Purchase, the Treaty of Guadalupe Hidalgo (Sax and Abrams, 1986). At the time, the government was not expected to be a landowner of vast tracts of land and had no provision to do so. In the 19th century, Congress, had to develop a policy for the lands. This policy became one of settlement. The federal government permitted and encouraged the transfer of lands into private holdings. However, responding to new and changing ideas around the turn of the century, the federal government began to withdraw tracts of land from settlement to reserve them for federal purposes such as Indian reservations, military reservations, national parks, and national forests. The federal policy of settlement and disposal continued until officially terminated when Congress passed the Federal Land Policy and Management Act of 1976 (Sax and Abrams, 1986).

On May 1, 1888, the Fort Belknap Indian Reservation was created in Montana. The Milk River ran through it. In 1900, non-Indian settlers living upstream from the reservation began to divert water from the Milk River, preventing the Indians on the reservation from getting sufficient water for irrigation. The United States brought suit on behalf of the Indians against the settlers. The Supreme Court, in *Winters v. United States* (1902), generally regarded as the cornerstone of Indian and federal reserved water rights, ruled in favor of the Indians (although with culturally archaic reasoning). The argument went as follows: "It was the policy of the Government, it was the desire of the Indians, to change those ['nomadic and uncivilized'] habits and to become a pastoral and civilized people." Understanding that the land in question was arid and virtually useless without irrigation, the Court reasoned the Indians did not relinquish command of the waters, for "it cannot be supposed that the Indians were alert to exclude by formal words every inference which might mitigate against or defeat the declared purpose of themselves and the Government..." Further, "that the Government did reserve [the waters] we have decided, and for a use which would be necessarily continued through years. This was done May 1, 1888..." (Trelease, 1974). The tenets of Indian reserved water rights stemming from this case, commonly known as the Winters doctrine, are that water was reserved for the purpose for which the reservation was established; that the reservation of sufficient water was for present and future needs; and the date of the right is the date the reservation was established. As an aside, the decision also declared that "By a rule of interpretation of agreements and treaties with the Indians, ambiguities occurring will be resolved from the standpoint of the Indians." This facet of the decision appears to have been largely ignored since that time.

For the next 50 years, the federal government continued to represent Indians (sometimes against their consent) in water rights disputes, resulting in three significant decrees (Burton, 1991). In the 1910 Kent Decree, the 1935 Globe Equity Decree, and the 1944 Orr Ditch Decree, the government, acting without or with grudging consent of the Indians involved, negotiated settlements on behalf of the Indians with neighboring non-Indians. The Indians later maintained they were pressured into accepting the terms of the negotiated settlements which were generally unfavorable, but subsequent courts refused to reopen cases. The decrees have caused deep Indian resentment toward non-Indians and the federal government (Burton, 1991).

A significant case concerning Indian water rights was *Arizona v. California* (1963, 1964). In this case, the court held that since five reservations along the Colorado River had been established to facilitate Indian agriculture, the Indian entitlement was enough water to irrigate all the "practicably irrigable acreage" (PIA), subject to appropriate adjustment. Thus, the quantity of water was not limited by the specific number or needs of the Indians. This case established the PIA measure quantifying Indian reserved water rights.

The PIA standard, while seemingly generous to the five Colorado River tribes, has had severe problems in practice. Not all Indian reservations were set aside for agricultural purposes, nor are mainstay agricultural practices possible or desired, as is the case for reservations where fishing, timbering, mining, or recreational pursuit might be the major economic activity (Getches, 1984). In addition, the determination of PIA is neither simple nor quick--especially if done correctly (Shupe, 1985). It involves extensive investigation by hydrologists, soil scientists, agronomists, economists, and engineers to (1) identify arable land on the reservation, (2) determine feasible cropping patterns, (3) calculate the amount of water needed by crops, (4) design an irrigation system to deliver water, and (5) perform an analysis--a cost-benefit study, the court stipulated--of the crop mix, production, and irrigated land management practices. Nonetheless, the PIA standard as applied to the five Indian reservations was considered fairly generous; the tribes were awarded nearly 1,000,000 acre-feet of the 7,000,000 acre-feet of water that was to be partitioned amongst the lower Colorado states.

In *Colorado River Conservation District v. United States* (1976), the court held that the McCarran Act of 1952, in which the federal government consented to be a defendant in a suit for the adjudication of water rights in a state court, was applicable. The court held that it made sense to transfer a federal Indian water rights case to a state court which was simultaneously conducting a comprehensive adjudication involving the same bodies of water. In a later case, *Arizona v. San Carlos Apache Tribe of Arizona* (1983), the court again held that the sovereign immunity of the United States in a comprehensive state water adjudication was waived in order to avoid "piecemeal adjudication of water rights in a river system" (Amundson, 1986). The United States could still assert its rights in a state court.

Two other significant decisions were reached in 1983 regarding Indian water rights. *Arizona v. California* (1983) was reopened as Indians sought to have the amount of water based on PIA increased due to errors in and changes to the original calculations. Additional water, based upon tribal boundary changes, was accepted by the court. The argument that PIA should be increased because some lands were omitted from the original calculations was rejected, based upon the principle of the finality of legal decision (*res judicata*) (Black, 1979). The principle of *res judicata* was again asserted in *Nevada v. United States* (1983), even though circumstances might change or unforeseen issues not previously litigated might arise. The relitigation of Indian water rights was rejected because, the court maintained, at the time of the original litigation and subsequently accepted decree, all parties intended the determination of water rights to be final.

Two court cases of the 1970's, while not specifically mentioning Indian water rights, pertained to the nature of the federal reserved right in general. In *Cappaert v. United States* (1976), the "desert pupfish" case, the court held that nearby groundwater pumping which affected a limestone cavern that provided the habitat of the fish mentioned in the proclamation establishing the Devil's Hole National Monument must cease. In *United States v. New Mexico* (1978), the court rejected the claim that the government could reserve rights for wildlife, recreation, aesthetic purposes, and stockwatering in a national forest, because the purpose for which the national forest was established in 1899 was for timber supply and watershed protection only. Both of these cases reasserted that federal reserved rights applied to the original purpose for which land was reserved. (*Cappaert* is important to the case law dealing with groundwater, as it was one of the first federal cases in which a groundwater-surface water connection was implied).

Simms (1980) stated "the basis of Indian water rights claims derive from governmental indifference..." But, while the evolution of Indian water rights can be described as "one step forward, two steps back", the essence of the *Winters* decision has been upheld. Aspects of Indian and federal reserved water rights that have emerged are:

(1) the rights are not based upon use. They were implied when the reservation was established.

(2) the rights are potential, available for use if and when needed.

(3) they are not subject to state law in terms of definition, beneficial use, forfeiture or abandonment, or non-use as are water rights perfected under the doctrine of prior appropriation.

(4) the rights are unquantified unless quantified by legislation, litigation, or settlement.

(5) the rights are established as of the date the reservation was set aside. This is the only aspect consistent with state prior appropriation systems. However, most Indian reservations were established in the late 19th century and early 20th century, prior to the bulk of water rights perfected under state laws and codes.

A distinction between federal reserved rights and Indian water rights is that the federal government is not the owner of Indian water rights, but a trustee. While the government may manage (sell, lease, trade, etc.) its federal lands, its management of

Indian lands and associated water rights is constrained by its trust responsibility to the Indians (National Water Commission, 1973).

2.2 The Negotiated Settlement of Indian Water Rights Conflicts

The incompatibilities of two water right doctrines governing the use of the same resource creates an environment ripe for conflict. Despite nearly 90 years of activity, the uncertainty surrounding Indian water rights regarding jurisdiction, quantity, uses, and representation remains. To non-Indians, this uncertainty is becoming an impediment to water use, planning, and management. To Indians, this same uncertainty means they cannot and may not want to be exempt from water-related decision making throughout the West. In fact, the ambiguity surrounding Indian water rights is becoming a tool more forcefully and successfully asserted by the Indians, as the impact and priority of potentially large claims are realized and become more critical.

Nevertheless, new strategies, or rather, new success with the same strategies for the resolution of Indian water rights conflicts are emerging. Generally, Indian water rights conflicts are resolved by judicial action, which may be supplemented by legislation. The means by which settlement is reached, however, can be assisted through the negotiated agreement of the conflicting parties. Negotiated settlements, therefore, can occur within or as part of judicial adjudicatory proceedings. Within the past 15 years, the majority of Indian water right settlements have resulted from negotiated solutions in which Indians have been willing participants (Burton, 1991). A recent survey has shown 17 finalized settlements (Table 2.1) and 18 settlements underway throughout the West (Table 2.2).

Table 2.1 Indian reserved water rights settlements, 1962-1994. (Source: Office of the Special Master, October 1995).

STATE	TRIBE (DATE OF SETTLEMENT)
Arizona	Ak Chin Indian Community (1978, 1984, 1992)
	San Xavier & Shuck Toak Districts of Tohono O'odham Nation/Southern Arizona Water Rights Settlement (1982, 1992)
	Salt River Pima-Maricopa Indian Community (1988)
	Fort McDowell Indian Community (1990)
	San Carlos Apache Tribe (1992)
	Yavapai-Prescott Indian Tribe (1994)
California	La Rincon, San Pasqual, Pauma & Pala Bands of Mission Indians/San Luis Rey (1988)
Colorado	Southern Ute & Ute Mountain Ute Tribes (1988)
Idaho	Shoshone-Bannock Tribes/Fort Hall Reservation (1990)
Montana	Assiniboine-Sioux Tribes/Fort Peck Reservation (1985)
	Northern Cheyenne Tribe (1992)
Nevada	Fallon Paiute Shoshone Tribes/Truckee-Carson-Pyramid Lake Paiute Tribe (1990)
New Mexico	Navajo Nation/Navajo Indian Irrigation Project (1962)
	Jicarilla-Apache Tribe (1992)
Utah	Ute Tribe/Uintah & Ouray Reservation (1965, 1992)
Washington	Payallup Tribe (1989)
	Yakima Indian Nation/Yakima River Basin Enhancement Project (1994)

While they involve different circumstances, common elements of negotiated solutions have emerged (Lord et al., 1989; Checchio and Colby, 1993):

- awards and sources of water entitlements to the Indians are specified; reliability of sources is ensured. Indians give up Winters claim to water.

Table 2.2 Ongoing Indian water rights negotiations involving the U.S. Department of the Interior, 1995. (Source: Office of the Special Master, October 1995).

STATE	TRIBE	STATUS
Arizona	Gila River Pima-Maricopa Indian Community	Negotiations underway
	Navajo Nation, Hopi Tribe, San Juan Southern Paiute Tribe, Zuni Tribe	Combined negotiations underway
California	Big Pine Band of Owens Valley Paiute Shoshone Indians	Combined negotiations involving five tribes commenced in Sept. 1995
	Soboba Band of Luiseno Mission Indians	Negotiations underway
Idaho	Nez Perce Tribe	Awaiting tribal settlement proposal
Montana	Blackfeet Tribe	Formal negotiations terminated by Tribe; informal negotiations continue
	Crow Tribe	Information gathering; negotiations slow due to other negotiations in state
	Chippewa-Cree Tribe/Rocky Boy Reservation	Negotiations underway
	Fort Belknap Indian Community	Revised tribal proposal expected in Dec. 1995
Nevada	Shoshone-Paiute Tribes/Duck Valley Reservation	Negotiations with Nevada users underway; negotiations with Idaho users less active
	Las Vegas Tribe of Paiute Indians	Adjudication recently filed by state; preliminary discussions underway
New Mexico	Pueblos of Nambe, Pojoaque, San Ildefonso & Tesque	Non-Indian parties discussing proposal submitted by Pueblos in Dec. 1994
	Pueblos of Zia, Jemez & Santa Ana	Negotiations hampered by lack of non-Indian participation
	Pueblos of Acoma & Laguna	Negotiations delayed by Pueblos developing their positions and parties awaiting ruling from state appellate courts

Table 2.2 (continued)

STATE	TRIBE	STATUS
New Mexico	Taos Pueblo	Non-Indians submitted proposal in Aug. 1995; negotiations underway
	Zuni Tribe	Tribe preparing for negotiations
Oregon	Confederated Tribes of Warm Springs Reservation	Negotiations suspended in Dec. 1994; parties attempting to restart negotiations
Utah	Shivwits Band of Paiute Indians	Parties exchanged proposals in 1995; negotiations underway

- no uncompensated diminution of water rights of non-Indian water users.
- federal financial responsibility for all or most of the costs incurred, with the federal contribution averaging about $50 million per settlement.
- federal water supply augmentation in those instances where appropriable water resources were insufficient to support the award of rights to Indians.
- trust fund established for the Indians.
- negotiations are usually initiated by litigation and assisted by federal legislation.

The willingness of Indians to participate in negotiated settlements initially appears surprising. Burton (1989, 1991) stated that Indian water right conflicts, as compared to other natural resource conflicts, have been resistant to negotiated settlement. Historically, Indians have suffered sometimes disastrous losses of their water and claims to water in past settlements for which they are still seeking redress. They claim that they were misrepresented by the federal government and were coerced into acceptance of settlements they might not have accepted otherwise. The result has been contentious relations underway between Indians, the federal government, and non-Indians. The Indians have a justifiable mistrust of the willingness of the federal government and non-Indians to keep the promises made in negotiation.

However, there are several factors that explain the willingness of Indians to participate in negotiated, as opposed to adjudicated, settlements. Historically, Indians have not fared well in state courts. State court judges are elected by popular vote and (not to imply that justice is popularly determined) may be more sympathetic to hardships that potentially large federal claims might cause to the majority of its residents. The apparent abandonment of the Indians by the federal judiciary (the Indians' ostensible champion), as exemplified by the *Colorado River Conservation District v. United States* (1976) and its legacy to state courts, adds to Indian wariness.

Generally, the federal support for Indian water right protection appears to be diminishing. An examination of completed and on-going settlements indicates that the Indians may be lured by the award of "wet" water versus "paper" water. Indians are often more familiar with paper water, which "consists of a legal right to water that is not available for use", than with wet water or "water that can actually be utilized..." (McCool, 1989). The award of not only water, but the means to utilize it, has been a common feature of negotiated settlements.

State adjudication proceedings leave all but the legal claim to water unanswered. Issues regarding use, financing, off-reservation leasing of water, even notions of compensation for past mismanagement of Indian water, remain. These issues become central to negotiated settlements.

Finally, if negotiations do not go well, litigation remains a viable option for the Indians. While a risky strategy fraught with unpredictability for both Indians and non-Indians, the priority of Indian claims coupled with the PIA standard has been relatively well-established. The Indians have become more adept at using the threat of litigation as a means to strengthen their bargaining position if and when disputes are settled.

The willingness of non-Indians to negotiate is obvious. First, non-Indians want to avoid drastic losses of the water they are currently using and that the federal government "developed" for their use. Second, quantification of Indian water rights is becoming an ever-increasing concern as pressures grow for the use of a limited resource. Third, non-Indians want to ensure that Indian use of water does not have detrimental effects off the reservation in terms of water markets and environmental impacts. Finally, non-Indians have the ability to negotiate. Currently, non-Indians have the water, the money (albeit limited), and means to use and trade water to achieve their goals.

Both Indians and non-Indians have reasons to consider an alternative to unassisted litigation (adjudication). Litigation is costly, time-consuming, polarizing, and claim-oriented only. Meanwhile, there are mutual benefits that can accrue to both Indian and non-Indians through negotiated settlement. Negotiation can address issues of administration and enforceability of award. Recent settlements have included relatively generous monetary awards supplied by the federal government. These awards have done much to satisfy the Indian need to put the water to work, and toward relieving non-Indians of the burden of providing those awards. The federal attitude towards negotiated settlement is evidenced by the existence of the Department of the Interior's Working Group on Indian Water Rights Settlements and the 20 federal negotiation teams now operating throughout the West. Secretary of the Interior Bruce Babbitt secured a commitment that there would be no budgetary opposition by the administration to Indian land and water right settlements "as long as cumulatively they did not exceed $200 million per year" (Office of the Special Master, October 1995). However, in an era of extreme scrutiny of federal expenditures and budget tightening, the federal contribution is expected to dwindle. Indians and non-Indians recognize how crucial the federal contribution has been to negotiated settlements and conflict resolution. The continuing decline of federal contribution adds a strong and immediate impetus to negotiate a mutually acceptable settlement while funds are still available.

The two issues that emerge in strategy choices for conflict resolution are control of the outcomes and goal achievement. As Folk-Williams (1988) wrote, "Self-interest of the parties is the ultimate arbiter of which procedural path will be utilized."

The negotiated settlement of Indian water rights is not without criticism. Negotiation is ad hoc and particular to the communities and circumstances involved. Issues of equity arise (Burton, 1991). More serious charges are that the federal government's apparent policy implies termination of federal involvement in Indian water rights and abandonment of its trust responsibility (Wallace, 1985; McGuire, 1992).

Additionally, the process of reaching a negotiated settlement is neither simple nor direct. The process requires that affected parties be identified, empowered, and that they participate. Proper resources and data must be gathered and/or generated. At least one acceptable settlement option must be found. (These three components are, to varying extents, the topics which this study addresses). Once generated, the settlement must be approved by various entities. Local and tribal approval is required, and state approval may be required. Federal approval is crucial due to its trust responsibility and because it is usually a significant funding source. Some aspects of the settlement require court approval; for example, in a general stream adjudication, a settlement among parties would be entered as a final decree. In reality, the process is iterative.

Nonetheless, the potential of negotiation cannot be overlooked. A sense of urgency and a need to control outcomes combine to ensure that negotiated settlements are viable resolution methodologies, despite the dim results of the earliest settlements. According to one tribal leader, “If we wait too long, there won’t be a resource left to negotiate.” A staff member to the Assistant Secretary for Indian Affairs stated, “If the pie is going to be carved up, it’s better that we do it ourselves than let the court do it for us” (Checchio and Colby, 1993). While the process is complex, settlements negotiated in a process that acknowledges the physical, political, financial, and social realities of the dispute may help in simplifying the process and ensuring the result.

CHAPTER 3

CASE STUDY

The land area of Arizona is roughly 75 million acres. The total area of Indian reservations within Arizona is approximately 25 million acres (Eden and Wallace, 1992). A review of negotiated Indian water right settlements completed or underway, shows that Arizona has emerged as a leader, if only by necessity. In this chapter, the particulars of the on-going proceedings will be presented, followed by a description of the San Pedro River Basin, a tributary to the Gila River, where the possibility of a negotiated resolution to Indian water rights conflicts will be explored.

3.1 The General Adjudication of the Gila River System and Sources

3.1.1 The Gila River

The Gila River is the second largest river in Arizona. Originating in western New Mexico and flowing west to its confluence with the Colorado River, the Gila River has a drainage area of approximately 58,000 square miles (USGS, 1988). The Gila River flows through the hot, dry, populous southern half of the state of Arizona. The river no longer flows continuously throughout its length because irrigation withdrawals now result in nearly complete depletion of surface water within the Gila River.

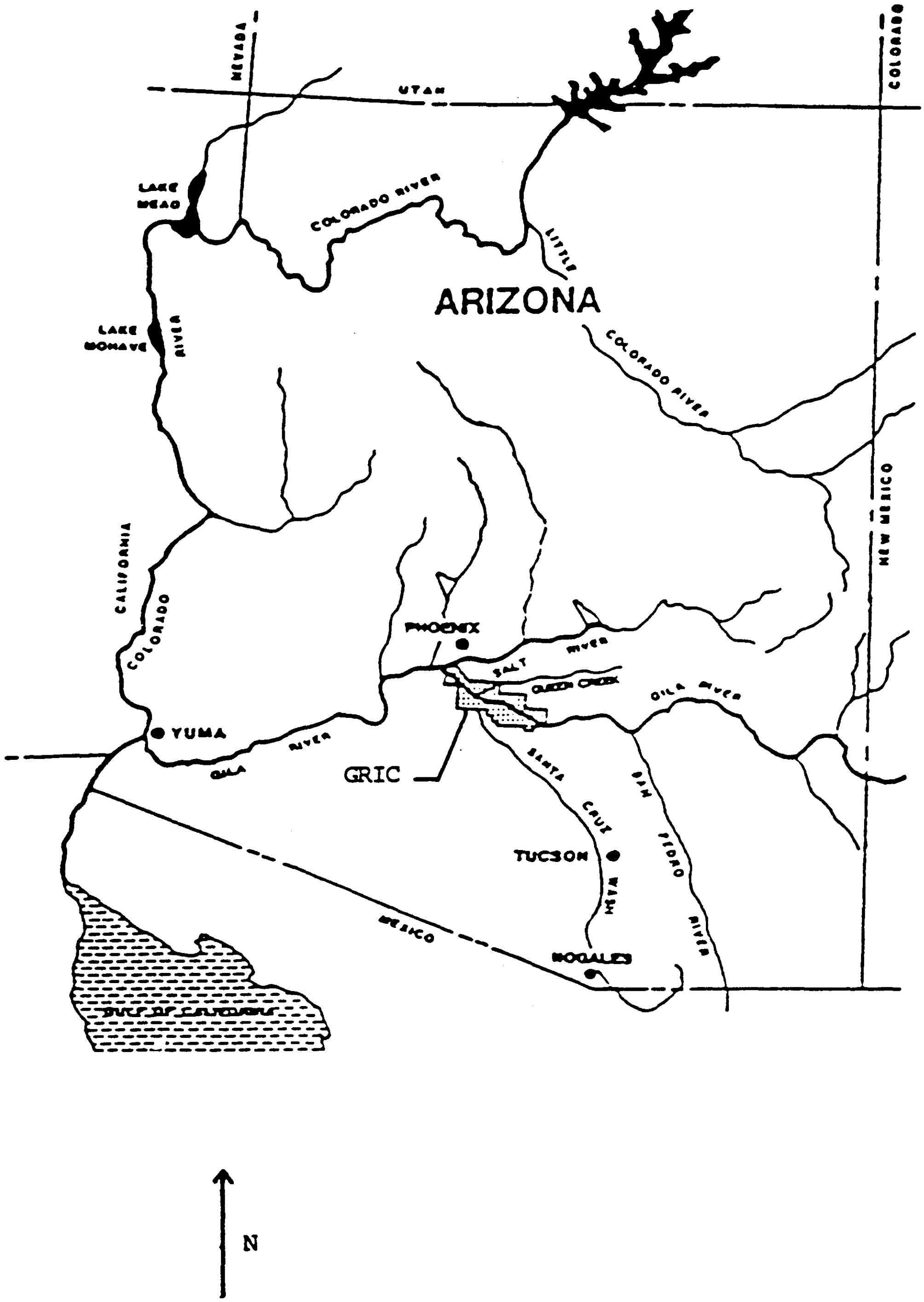
3.1.2 The Gila River Indian Community

The Gila River Indian Community (GRIC) is located along the banks of the Gila River about midway along its length (Figure 3.1). Established in 1859 (Munderloh, 1996), the GRIC is home to the Pima and Maricopa Indians, descendants of the prehistoric Hohokam who were well-known for their extensive canal systems, some of which are routes for the modern canal system supplying the nearby Phoenix metropolitan area. The GRIC encompasses 372,932 acres (Eden and Wallace, 1992).

The Gila River flows northwest through the GRIC. Near the upstream (eastern) boundary of the GRIC, an average of 400,000 acre-feet of water is diverted annually at the Ashurst-Hayden Dam upstream from the GRIC. A portion of the diverted water is supplied to the GRIC for irrigation purposes. Discharge of the Gila River below the dam averages 600 acre-feet per year. Frequently, no water is discharged from the dam. This implies that Gila River flows are now almost completely used, leaving little or no surface water to satisfy Indian claims.

The GRIC commissioned a master plan for reservation development. The 1985 plan detailed current and planned land and water uses. Under the plan, agricultural land use and development would increase as would industrial land use. Provision was also made for the re-establishment of a riparian habitat along the banks of the Gila River within the GRIC. The water requirement for the planned land uses totaled 791,000 acre-feet (Bazlen, 1989). Presumably, the water would come at the expense of current non-Indian water users.

Figure 3.1 The Gila River Indian Community, Arizona. (Source: Bazlen, 1989).



3.1.3 The Proceedings

Like a river, the General Adjudication of the Gila River System and Sources had modest beginnings. On April 26, 1974, the Salt River Valley Water Users Association (SRVWUA) filed a petition with the Arizona State Land Department for an adjudication of the upper portion of the Salt River, a major tributary to the Gila River. In 1976, the SRVWUA filed another petition for the adjudication of the Verde River, a tributary to the Salt River. Phelps Dodge filed a petition in February 1978 for adjudication of the Upper Gila River. In April 1978, the American Smelting and Refining Company (ASARCO) filed a petition for adjudication of the San Pedro River, a tributary to the Gila River. In June 1978, the GRIC filed another petition for the adjudication of the San Pedro River in federal court. In late 1980 and early 1981, the Lower Gila River and Agua Fria River (still another tributary of the Gila River) were brought into the proceedings. In October 1985, the Upper Santa Cruz became the last river system added to the proceedings (Humphrey, 1988).

The Gila River Adjudication now encompasses nearly 25,000 parties asserting about 62,000 claims (Erb, 1988). Currently, the largest single claim, by the GRIC, amounts to 1,599,252 acre-feet (Eden and Wallace, 1992). As of June 1990, 8,033 claims have been filed for rights to water within the San Pedro Basin (Arizona Department of Water Resources, 1990).

Since 1985, adjudication proceedings have made administrative and procedural progress, but very little substantive progress. A substantive hurdle encountered early on was the issue of groundwater/surface water connection. On September 9, 1988, the presiding judge issued a statement that groundwater pumped from wells where the volume of nearby surface flows was depleted by 50% or more after 90 days of continuous pumping was subject to adjudication (Goodfarb, 1988). This became popularly known as "the 50-90 rule." In 1993, the Arizona Supreme Court voided the 50-90 rule partially because "subflow" was not defined. Subsequent attempts at definition have met with similar results or are pending (Bouwer and Maddock, 1996).

A second major hurdle facing the adjudication proceedings is jurisdiction. On March 17, 1995, House Bill 2276 was signed into law by the Arizona legislature. The law stated that water rights of 3 acre-feet per year for domestic use and 15 acre-feet per year for stockwatering should be adjudicated automatically--in essence, removing those claims from the proceedings. The United States and several Indian tribes united to petition the Arizona Supreme Court to declare the law unconstitutional on the basis that the removal of those rights negates the comprehensiveness of the proceedings, thus negating the applicability of the McCarran Amendment. Under the McCarran Amendment, the United States and Indians must allow their water rights to be adjudicated in state courts if the adjudication proceedings are comprehensive (Office of the Special Master, June 1995). If the state proceedings are not comprehensive, Indian and federal reserved rights remain outside the jurisdiction of state courts. Arizona Supreme Court Chief Justice Stanley G. Feldman stated, "...these new objections will delay all proceedings by approximately three years" (Office of the Special Master, October 1995).

Still, a Gila River negotiation team has been established, and a water right settlement value of 700,000 acre-feet per year has been proposed by the GRIC (Munderloh, 1996).

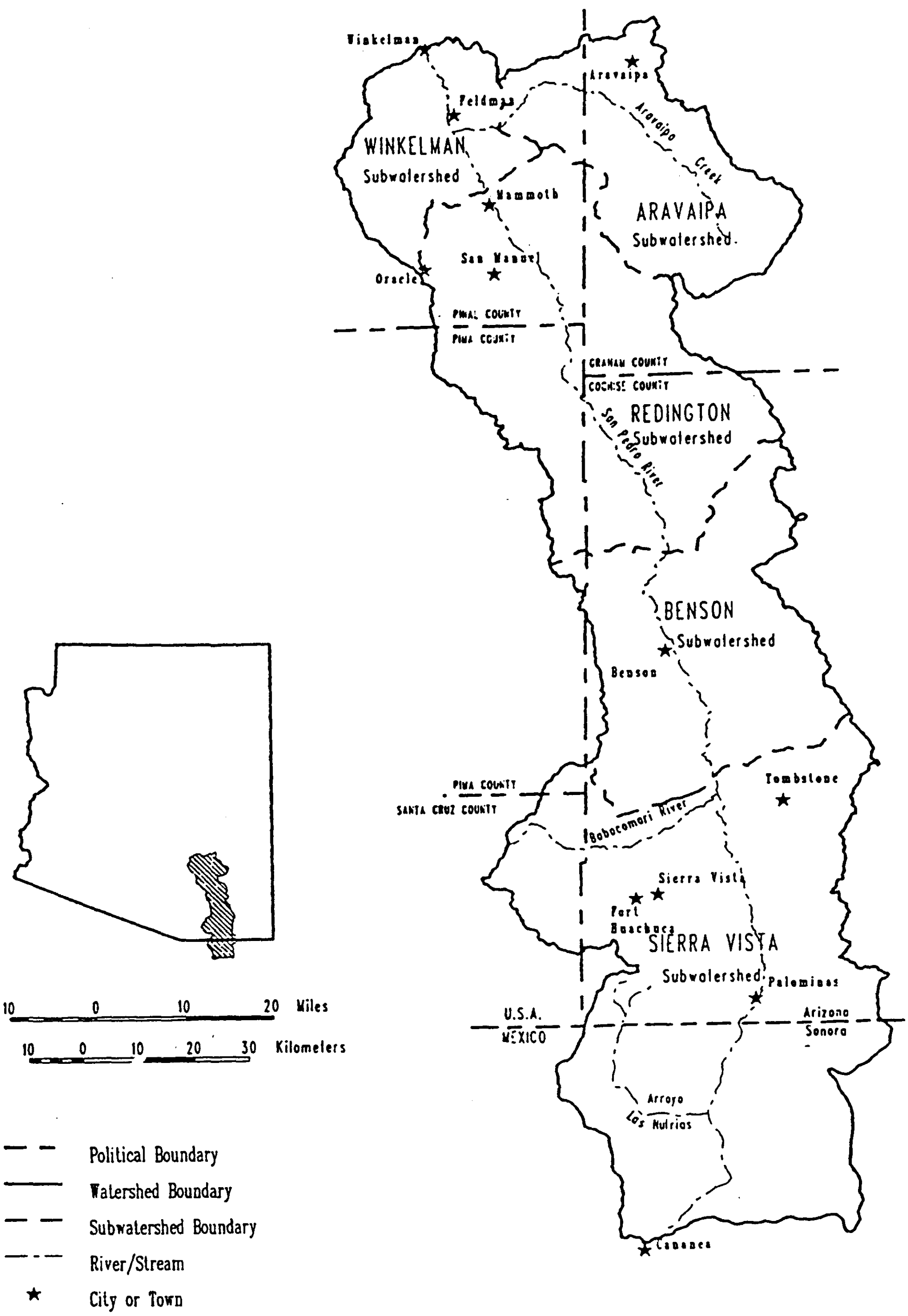
3.2 The San Pedro River Basin

3.2.1 The Physical Setting

The San Pedro River Basin is a north-northwest trending basin in southeastern Arizona. The area of the Basin is 4485 square miles, with 696 square miles of its headwater area in Mexico (Figure 3.2). Typical of the basin and range physiographic region, the Basin is elongated, defined by linear mountain ranges, with the San Pedro River flowing north along the central axis until its confluence with the Gila River at Winkelman. The climate of the Basin is semi-arid, with average annual precipitation ranging from 35 inches in the mountains to 12 inches in the lower valley. Daily temperatures in the valley average 84 degrees Fahrenheit. Summer temperatures can exceed 100 degree along the valley floor. Snow is common in the mountains during the winter, but rare in the valley (Arizona Department of Water Resources, 1990).

Precipitation is dominated by convective activity, with moisture originating from the south (Gulf of Mexico, Gulf of California), during the summer months of July, August, and September. This precipitation is characterized by brief, intense, and localized periods of rainfall. A secondary period of precipitation occurs during the winter months of December, January, and February, where periods of precipitation are generally less intense, of longer duration, and cover a larger area than in summer. This

Figure 3.2 The San Pedro River Basin, Arizona. (Source: Arizona Department of Water Resources, 1990).



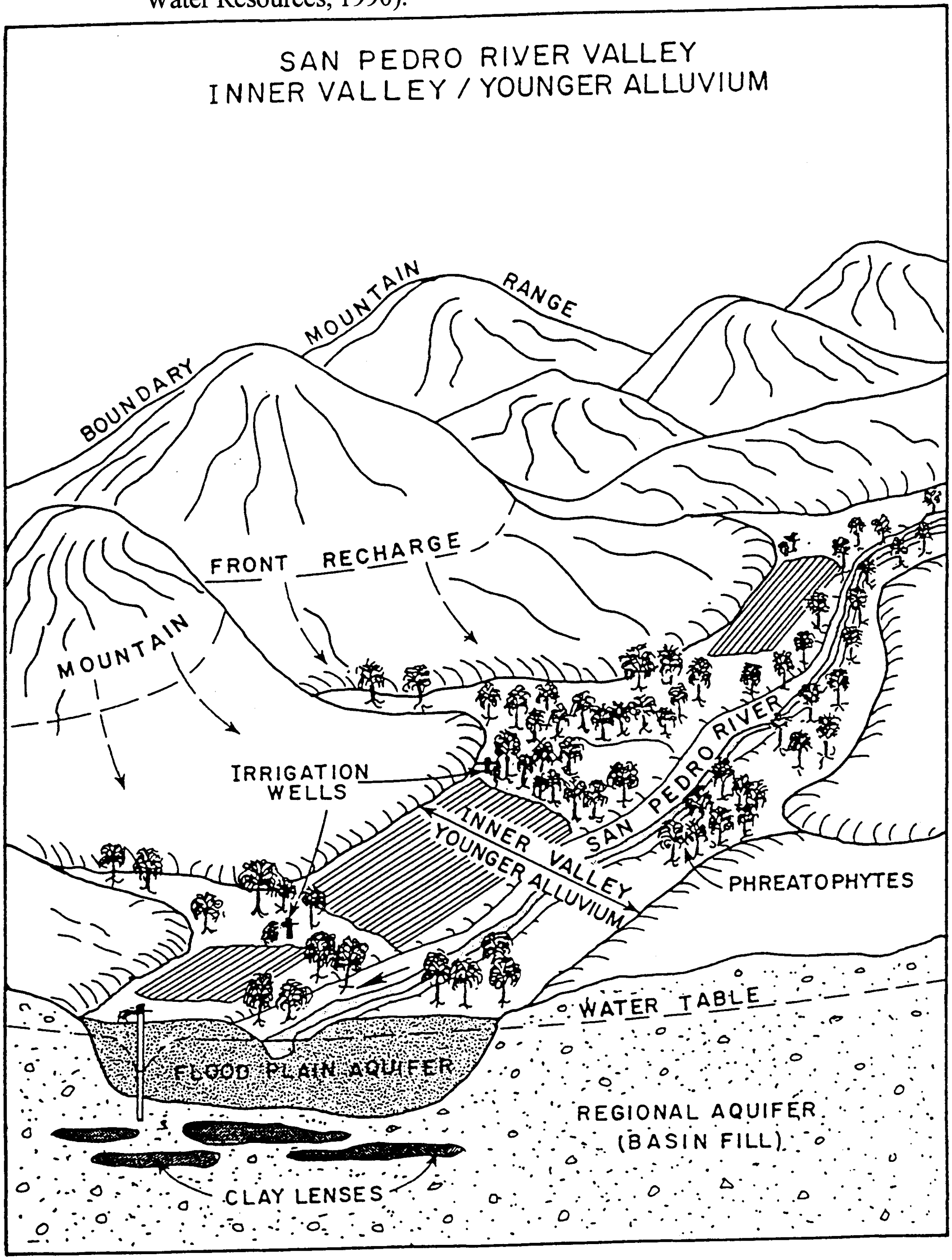
precipitation is usually in response to frontal activity originating in the north Pacific. The months of April, May, and June are typically the hottest and driest months.

Runoff along the ephemeral reaches of the San Pedro River is in response to snowmelt or intense precipitation. Other reaches flow perennially, usually due to geologic controls or perched groundwater tables. Average annual flow of the San Pedro River for the period 1968 to 1976 was 17,000 acre-feet near the US-Mexico border, 22,800 acre-feet at Redington (roughly at the midpoint of the Basin), and 35,000 acre-feet at the confluence with the Gila River. The largest annual discharge for the same stations was 59,000, 130,000, and 87,900 acre-feet, respectively (ADWR, 1990). Periods of no flow have also been recorded at all three sites (USGS, 1974).

The valley fill is composed of relatively loose, unconsolidated alluvial material. The majority of the alluvial material is comprised of gravels, sands, silts, and clay beds forming a regional aquifer for the subsurface storage and transmission of water toward the valley center. The looser, more unconsolidated and porous material immediately surrounding the river, known as the floodplain aquifer, is composed of primarily sands and gravels of younger geologic age than the older regional aquifer material (Figure 3.3). Lateral geologic constrictions of the aquifer system define hydrologic sub-units within the Basin. The major constriction at Redington generally serves to distinguish the Upper and Lower San Pedro Basins.

The vegetation in the valley in the upper portion of the San Pedro Basin is typical of that within the Chihuahuan Desert--dominated by grass and shrubs. The

Figure 3.3 Cross section of the San Pedro Basin. (Source: Arizona Department of Water Resources, 1990).



valley vegetation in the lower portion of the San Pedro Basin, is more typical of the Sonoran Desert--dominated by shrub and cactus. Pine vegetation dominates the mountain areas, which grades through oak-juniper woodlands to the valley floor. Riparian vegetation dominated by cottonwood, mesquite, and willows immediately adjoins the river. Most of these species are phreatophytes and have extensive root systems tapping the surrounding aquifer. These areas of riparian vegetation are associated with perennial reaches and are unusually rich and diverse in terms of both plant and animal species (Lacher, 1994).

The properties of the areas immediately surrounding the river channel--relatively flat and constant topography, deep and well-aerated soils, and relatively high water table--are attractive not only for riparian species, but for irrigated agriculture as well. However, riparian vegetation and irrigated agriculture cannot occupy the same space.

3.2.2 Water Use Within the San Pedro Basin

According to annual figures reported by the Arizona Department of Water Resources (1990), cultural water uses (including irrigation, domestic, municipal, stockwatering, mining and industrial uses) throughout the San Pedro Basin amounted to 83,580 acre-feet annually. Water used for irrigation, which generally occurs within areas underlain by the floodplain aquifer, amounted to 45,610 acre-feet annually. Approximately 67% of that water use occurred within the Upper San Pedro Basin; the remaining 33% within the Lower San Pedro Basin.

Natural depletions to flow (due to channel evaporation and primarily to phreatophyte use) equaled 61,560 acre-feet per year. About 56% of that loss occurred within the Upper San Pedro Basin, and 44% within the Lower San Pedro Basin.

3.2.3 Related Issues

In 1988, the United States Congress established the San Pedro Riparian National Conservation Area (SPRNCA), the first such preserve in the United States. The area was preserved "...to protect the riparian area and the aquatic, wildlife, archaeological, paleontological, scientific, cultural, educational, and recreational resources of the public land surrounding the San Pedro River..." (S. 2840, 1988). Managed by the Bureau of Land Management (BLM), the SPRNCA encompasses 56,400 acres, forming a narrow strip of federal land along the San Pedro River. Local environmental groups consider this area to be extremely important for ecosystem biodiversity.

The community of Sierra Vista and the Fort Huachuca military reservation are also located within the Upper San Pedro Basin. Sierra Vista is popular for its mild climate, while Fort Huachuca is a major military base, which has grown in population despite recent military base closures nationwide. The communities have experienced a combined population increase of 44% from the period 1980 to 1990. The current (1995) population is estimated at about 40,000. Both communities are totally dependent upon groundwater and pump exclusively from the regional aquifer.

There is local concern that groundwater pumping in the Sierra Vista/Fort Huachuca area may adversely affect streamflow in the SPRNCA. In a recent study, Vionnet (1992) simulated decreases in surface flow due to continued groundwater pumping of the regional aquifer.

The known hydraulic linkage between the regional aquifer, the floodplain aquifer, and flows in the river contrasts markedly with the legal separation between the regional aquifer and the floodplain aquifer/river system. The critical factor is time, because the effect of groundwater pumping can be discerned much more rapidly within the floodplain aquifer/river system than between the regional aquifer and floodplain aquifer. The issue is quite controversial, exciting much discussion.

CHAPTER 4

CONCEPTS AND METHODOLOGY

4.1 Concepts

Two earlier studies provide the conceptualization and components necessary to describe and, ultimately, aid in the resolution of Indian water rights conflicts. Rakshit et al. (1988) applied game theory to a hypothetical conflict involving Indians, non-Indians, and the federal government. They determined, in that case, potential negotiated solutions existed, but solution concepts were general--issues upon which to negotiate were not identified. Bazlen (1989) explored the possibility the Gila River Indian Community (GRIC) and San Pedro Basin water users could trade water and money to resolve the water right conflict.

Each tool was important individually, but a methodology was needed to bring these concepts to bear upon this study. Indian water rights conflicts are complex and multifaceted, and a single analytical tool (a hydrologic model, for example) is insufficient to capture many important aspects. Rather, the combined application of several tools may be necessary to capture the complexity and bring salient features to bear upon the central question. A rigorous, reproducible, and defensible framework can allow the exploration of the consequences of unknown or changing hydrologic, economic, or institutional information upon conflict resolution.

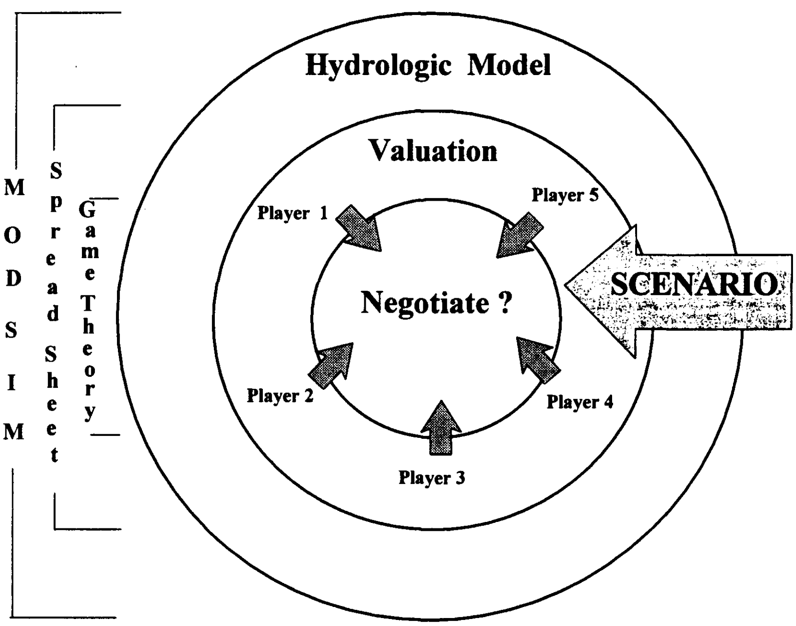
The available tools and linkages necessary to address the central issue of settlement alternatives were conceptualized as shown in Figure 4.1. Key features of this conceptualization are:

* The central decision for each participant is whether to negotiate or not.
* The central decision is a joint decision among participants.
* The outputs from one analytical tool or model become the inputs for another.
* Three tools to describe the circumstances of negotiation are available:
    - a hydrologic model, MODSIM, to represent water availability and use throughout the entire San Pedro Basin.
    - an economic valuation spreadsheet developed by Bazlen (1989) which transforms water into units meaningful to claimants (money, income levels, irrigated acreage, etc.)
    - elements of game theory which could be used to describe the decision making of the participants and assess the joint acceptability of negotiated settlement scenarios.
* This conceptualization allows the introduction of several scenarios (settlement options), each of which has to be evaluated individually by each player.

4.2 Methodology

A priori assumptions under which the framework was developed were formulated. It was assumed that negotiation would take place in a "friendly" environment, i.e. that no participant was acting to the intentional detriment of another participant. Furthermore, it

Figure 4.1 Conceptualization of available tools applied to Indian water right conflicts.



was assumed that the participants would communicate voluntarily, could agree to settle the dispute, would honor the settlement, were equally informed, and were of equal standing (each participant could veto any proposed settlement). It was assumed that the resolution would, minimally, have the characteristic of making no participant worse off by negotiating, and that at least one participant will be made better off (otherwise, why negotiate?)--the settlement was Pareto optimal. Optimistically, it was assumed that there may exist a "win-win" resolution so that all participants could be made better off through a negotiated settlement. In an overappropriated river system, or when demands are greater than the supply, the award of water to one claimant will entail the loss of water to another (more junior) claimant. Under the doctrine of prior appropriation, water one claimant "wins" the other "loses" exactly--a win-lose situation. Negotiated settlements, where more than just the simple award of water is made, can allow for the possibility that all participants can "win" something--a win-win situation. The point was to search for the win-win options.

4.2.1 Hydrology and Valuation

The need to organize water-related information to bear upon the conflict is obvious. The methodologies used will vary depending upon circumstance. However, two issues must be addressed. First, water supply and water use must be described as most water right conflicts are, ultimately, a conflict of water allocation. Second, if, as Bazlen (1989) suggested, water is valued differently by the disputants allowing trade as the basis for negotiation, a methodology is required to disintegrate possible negotiation options to allow for disputant valuation. The application of specific methodologies is described in the following chapter.

4.2.2 Game Theory

The mathematical theory of games provides a convenient model with which to examine Indian water rights conflicts. The following discussion is not a complete description of the theory of games, nor is it intended to be. The intent is simply to introduce and explain the terms and concepts used in the following chapters. For a more complete discussion of game theory, there is a substantial body of literature, notably that by von Neumann and Morgenstern (1964), Luce and Raiffa (1967), Davis (1970), and Rapoport (1970).

Developed by a mathematician and an economist, game theory is a branch of mathematics that concerns itself with conflicts (Luce and Raiffa, 1967). Using terminology borrowed from parlor games, game theory describes situations where there exist participants (Players) making decisions about how to proceed (Strategies), which will result in some final state (Outcome) with an associated reward (Payoff). Game theory incorporates the fact that one player may evaluate the outcomes differently than other players do, each according to his own tastes, desires, or preferences. Game theory posits that each player is attempting to achieve the highest level of desirability for himself, that other players are similarly motivated, and that each player only partially affects the outcome, which is shaped by the combined actions of all players, as in negotiated settlements. Game theory is an elegant tool in that it is simple, yet can illuminate several aspects of situations, both conceptually and with the use of more formal mathematics. Rapaport (1970) stated that, "the primary function of (game theoretic) analysis is not to predict, or even prescribe rational behavior, but to clarify and illuminate the issues in a decision problem."

4.2.2.1 Game theory and Indian water rights conflicts

To illustrate the potential of game theory, a simple example is presented. Suppose a conflict involved only two participants, Player I and Player II. Each player must decide whether to choose Action A or Action B. Each player recognizes the outcome of his/her choice will depend partially on the choice made by the other player. Additionally, each player also realizes that each action choice will yield a result relevant to each player and determined by the combined choices of both players. It is assumed that the players are strictly competitive--that they are adversarial--and that whatever payoffs one player wins, the other loses exactly (a zero-sum game). This can readily be illustrated by a game matrix (Figure 4.2).

Figure 4.2 Game matrix.

Player II	*B*	***Payoff (B,A)***	***Payoff (B,B)***
	A	***Payoff (A,A)***	***Payoff (A,B)***
		A	*B*
		Player I	

With this type of game theoretic notation, the choices both players have, as well as the outcomes that will ensue from those choices, can be made evident. In the game matrix, the outcomes are represented by the positions within the matrix and contain particular relevance to the player in the form of a payoff. Each player is assumed to prefer the highest possible payoff. This concept models player behavior within a game theoretic analysis. Game theory assumes "rationality" on the part of the players, i.e., they are playing to get the most for themselves. All players within this study were considered rational.

To continue the example, Player I represents the Indians and Player II represents the non-Indians. The strategies available to each player are Negotiate (Strategy A) or Not Negotiate (Strategy B). In this example, these strategies are considered mutually exclusive because the strategy choice B, not negotiating, automatically implies adjudication. A No Action strategy does not exist as, in reality, a No Action option will automatically result in adjudication. The game matrix is illustrated in Figure 4.3.

If both players choose to negotiate, the result is negotiation. If both players choose to adjudicate, or if they select unlike strategies, regardless of which ones, the result is adjudication, since negotiation can occur only when all parties agree to it.

In this example, a resultant payoff meaningful to each player is not stipulated, yet some value or indicator of payoff is theoretically possible. Even without assigned payoffs, the simple analysis indicates that: (1) it may be possible to design a negotiation strategy so that the outcome is sufficiently acceptable to make both players choose it; and (2) if the players are allowed to communicate and bargain, the possibility of them both choosing the negotiation strategy may be increased.

Although a large part of the game theoretic literature deals with the simple two-person zero-sum game, relatively few situations are that simple in reality. If, for example, an outcome was associated with the payoff of water, it cannot be assumed that the value

Figure 4.3 Game matrix of negotiate/adjudicate decision problem.

Non-Indians	*Indians: Negotiate*	*Indians: Not Negotiate*
Not Negotiate	***Adjudicate***	***Adjudicate***
Negotiate	***Negotiate***	***Adjudicate***

of a specified amount of water will be the same for Indians and non-Indians. The zero-sum game becomes a non-zero-sum game. Additionally, only two players were identified, but conflicts over Indian water rights never are confined to only two players. The federal government was excluded from the example but the trust responsibility of the federal government toward the Indians cannot be ignored, nor can its fiscal responsibilities toward the taxpayer. The addition of only a single player immediately moves the game to a more complex level of analysis. Finally, at the conclusion of the example, it was suggested that if the players were allowed to communicate (cooperate), they might be able to come to some mutually reasonable outcome. The simplest, most fully developed "two-person, zero-sum, competitive" game must be modified or augmented by other concepts to illuminate real world conflicts. Game theory uses terms such as *non-zero sum* games where the payoffs between the two players do not cancel each other out, *cooperative* games where players are not strictly competitive and are allowed to communicate freely and coordinate strategies, and *n-person* games which involve more than two players.

Cooperation, in game theory, is described as communication and binding agreements between players--in essence, the coordination of strategies. Game theory distinguishes between conflicts in which the participants are allowed to coordinate their strategies and those in which they aren't, although, in reality, there exist relatively few situations where pre-play communication is prohibited, either by social norms or legal prohibitions (anti-trust laws or insider trading). It is assumed, here, that cooperation is not by coercion, but is voluntary.

While descriptive outcomes sufficed for the previous examples, well-defined outcomes are necessary for a more realistic approach to solution identification. A procedure must be developed to collect and organize data for analysis. Game theory does not describe how to define strategies, outcomes, or payoffs--definition is a task based upon knowledge of the conflict environment. Steps to develop these will be discussed. Fortunately, the field of decision analysis (closely related to game theory) does concern itself with how payoffs can be calculated.

4.2.2.2 Scenarios

Scenario identification is an attempt to describe what is physically, economically, institutionally, and legally possible. To simplify the task of developing scenarios, it must be assumed that the choices open to each player are separate from any preferences of the player and disassociated from notions of payoff.

Negotiation scenario formation began by assuming that a scenario was the result of the combined actions of all players. It was necessary to identify actions possible for each player based on the elements of past negotiated settlements. Assuming water is conservative (it is neither created nor destroyed) but can be traded for money (which is not conservative), a single player could either (1) demand or provide (2) money or water. Four action choices then became available to (although not necessarily rational for) each player: demand money, demand water, provide money, or provide water. Additionally, it was assumed that a player could choose one or more actions at a time so that 1-, 2-, 3-, even 4-action options were available to each player--i.e., one player could demand money **and** demand water; another player could provide money **and** provide water **and** demand money from another player. Also, a no action option was allowed to broaden the set of realistic scenarios. Considering the permutations of these simple actions, the number of scenarios is large.

Fraser and Hipel (1984) discussed the need to remove some actions from consideration and suggested a removal scheme with four types of actions that can be removed. The most applicable of these are:

Type I Actions: logically infeasible actions. For example, a player could not provide and demand both money and water.

Type II Actions: preferentially infeasible actions. A player would not be expected to both supply and demand money.

It is obvious that additional rules for scenario formulation are necessary based upon the physical and institutional realities. First, the following assumptions were made: (1) all players acknowledge the legitimacy of the Indian claim to water; and (2) the actions included elements of adjudication so that adjudicated outcomes can be described. These two assumptions taken together imply, for the non-Indians, that the Indians may be awarded rights to water. Likewise, the Indians implicitly acknowledge they may not be awarded the rights to the water.

Next, specific rules had to be formulated based upon the general features of past negotiated settlements. These rules were:

1. Any action that involved the Indians providing water was unrealistic, since they seek more, not less water (however, this does not preclude Indian marketing of newly awarded water).
2. The federal government represents all its responsibilities so some federal actions could be the same as the Indians', but could also include actions not available to the Indians (while the Indians have no water to trade, the government does--the Central Arizona Project water).

The federal government can provide money or water or both; it can demand water or money, but only if providing water or money or both. The federal government would not choose no action since, for this study, the government is seen as fulfilling its trust responsibility to the Indians and serving non-Indian interests, too. It was willing to contribute money or water to resolve the conflict. Although the federal government does have limits, this perception is not unrealistic, as has been discussed earlier. Non-Indians cannot demand water from the Indians; they can provide water. Non-Indian water users cannot demand anything without providing something. Non-Indian water users can demand money as compensation.

4.2.2.3 Payoffs

Each combination of feasible player strategies must be associated with at least one outcome, resulting in payoffs to the player. Even if determining the outcomes themselves is trivial, in all but the most simple or contrived games, it is impossible to presuppose that they mean the same thing to all players. Each player has his own evaluation of each outcome, and these evaluations or preferences, when expressed as utility, constitute the payoffs.

The concept of utility provides a mechanism by which player preferences can be associated with factual data about the conflict and allow certain game theoretic solution techniques. Utility "...relates the goals of a player, whatever they are, to the behavior that will enable him or her to reach those goals...The person is not trying to maximize his utility...very likely he doesn't even know such a thing exists. A player may act as though he were maximizing his utility function..." (Davis, 1970). Luce and Raiffa (1967) noted that the concept of utility is a construct and it is difficult, if not meaningless, to quantify utilities in the real world. But, they added:

> "...one may contend that introducing the numbers does no harm, that they summarize the ordinal data in a compact way, and that they are mathematically convenient to manipulate...(But) one must keep in mind that it is meaningless to

> add two together or to compare magnitudes or differences between them. If they are used as indices in the way we have described, then the only meaningful numerical property is order. We may compare two indices and ask which is the larger, but we may not add or multiply them."

Utility, as interpreted for this study, is simply a single numeric measure of preference with certain minimal properties.

Multiattribute utility theory (MAUT) provides guidance for a decision maker who must choose among two or more alternatives. The choice may not be easy (else why the analysis?), as each alternative may have many dimensions. MAUT posits that possible outcomes can be decomposed into criteria or attributes which the decision maker values, and for which the decision maker has constant and well-defined preferences. Attribute values and preference are aggregated into single utility values. The steps common to MAUT procedures are:

1. Define alternatives and value-relevant attributes.
2. Evaluate each alternative separately on each attribute.
3. Assign relative weights to the attributes.
4. Aggregate the weights of attributes and the single-attribute evaluations of alternatives to obtain an overall evaluation of alternatives (von Winterfeldt and Edwards, 1986).

Individual player assessment criteria must be defined and player preference among those criteria discerned. Further assumptions relative to player payoffs may help simplify the task: (1) each player, in reality comprised of many individuals, is a collectively homogeneous group; (2) each player has one or more general goals or objectives which it hopes to achieve regardless of circumstances; attainment of those objectives motivates player choice; (3) those objectives may be nebulous, but there exist discrete tangible measures, one or more of which describe a single objective, and can be used in lieu of the actual objective (Boltan et al., 1983). Goals or objectives, as used by Boltan et al. (1983), are the valued attributes of possible outcomes.

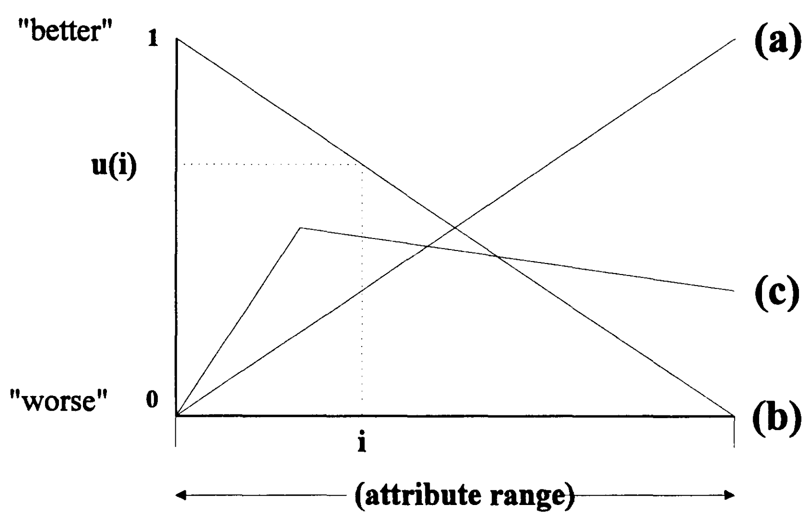
Player preferences among outcomes or their attributes must be elicited. In this study, MATS (Multi-Attribute Tradeoff System) an interactive personal computer-based program, was employed to discern player preferences and to develop scenario payoffs. MATS was developed by the Bureau of Reclamation (Brown et al., 1986) to aid in the analysis of multiattribute decision-making. MATS associates decisions (strategies) with plans (outcomes) which are, in turn, associated with valued attributes (criteria, goals, or objectives). The decision maker's preferences (weights) for these attributes are elicited, and preference scores for associated outcomes are calculated. MATS has the following components:

> *Factors* - attributes, goals, objectives, or criteria of the decision important to the decision-maker. If buying a car, factors might include acceleration, cost, and fuel consumption as measured by seconds to go from 0 to 60 mph, dollars, and miles per gallon ratings, respectively. For Indians, factors might include, for example, economic development as measured by median family income. The user must input a scale representing realistically high and low values for each factor.

Function Forms - a function that relates the level of attainment of each factor to desirability (utility)--"more is better", or "less is better." Graphically, Figure 4.4 shows function forms available in MATS. In buying a car, more acceleration is better, less cost is better. For the federal government, more riparian acreage is better, less federal expenditure is better.

Weights - the importance of a factor to a decision-maker. Using pair-wise comparison, MATS requires the user to choose between theoretical values for two factors until the user is indifferent.

Figure 4.4 Function forms available in MATS.



(a) "more is better"
(b) "more is worse"
(c) user defined

Plans - scenarios among which the decision-maker must decide.

Impacts - the values associated with each factor for each scenario. It was necessary to have the scenarios broken down into these components; hence the need for the valuation procedure (spreadsheet) performed prior to payoff determination.

The MATS formulae for computing plan scores (payoffs) are shown in Figure 4.5.

Figure 4.5 Calculation of payoffs using MATS.

$$P_k = \sum_{i=1}^{n} w_i u_{i,k}$$

where

P = payoff of scenario k
n = number of attributes
$u_{i,k}$ = the value of the utility function for attribute i for scenario k

$$w_i = \text{weight of attribute } i = \frac{wgt_i}{\sum_{j=1}^{n} wgt_j}$$

subject to

$$\sum_{i=1}^{n} w_i = 1.0$$

4.2.2.4 Solutions

Much of the decision analysis literature is concerned with finding optimal, or best possible, solutions. However, optimality is a meaningless notion in game theory and other multiple decision-maker problems, because interpersonal comparisons of utility are inadmissible. Payoffs cannot be aggregated across players, and thus, while individual optimality has meaning, collective optimality is meaningless.

For each player, scenario acceptability involved pair-wise comparison of the payoff of each negotiation scenario with the default adjudication scenario. The scenario with the higher payoff was considered a member of the (possibly empty) set of acceptable negotiation scenarios for the player.

Negotiation will proceed only if all players agree to do so. Therefore, scenarios that were acceptable to all players, i.e., the intersection of all individually acceptable scenario sets, constituted the set of jointly acceptable negotiation scenarios. If scenario 2 was acceptable to all players, then it was considered a jointly acceptable negotiation scenario and, therefore, a possible solution. A jointly acceptable negotiation scenario might not correspond to a single player's maximum payoff, but is a scenario in which each player would receive a higher payoff by negotiating than by adjudicating. The set of jointly acceptable negotiation scenarios could contain one or more scenarios; it could also contain none.

4.3 Summary

The theory of games provides an intuitively appropriate and conceptually simple framework with which to analyze Indian water rights conflicts. The definition of players making choices about a conflict which results in outcomes with associated payoffs forms the negotiated settlement model framework.

A step-by-step summary of the approach is given as follows:

1. Define players.
2. Describe the hydrology. Players need to know how much water they are dealing with.
3. Identify objectives for each player, then determine measure(s) for each objective.
4. Develop scenarios based upon hydrologic, legal, institutional, and political realities. In the context of Indian water rights disputes, some knowledge of elements common to successfully negotiated settlements is crucial.
5. Develop a valuation technique to transform scenarios into inputs for the payoff function.
6. Develop a payoff function utilizing those objective measures. A single payoff measure needs to be developed to aggregate objective measures. Player preferences need to be obtained.
7. Calculate payoffs for each player for each scenario. The payoff incorporates player objectives, preferences among those objectives, and some measure of attainment when compared to other payoffs of other scenarios.

8. For each player, compare negotiation scenario payoffs with the adjudication payoff. Those negotiation scenarios with payoffs higher than the payoff for adjudication comprise the set of acceptable negotiation scenarios.

9. Examine the set of acceptable negotiation scenarios for all players. The intersection of these sets will comprise the joint acceptable set of negotiation strategies.

CHAPTER 5

APPLICATION AND RESULTS

5.1 Hydrology

For this study, the maximum amount of San Pedro River water which the GRIC could claim was assumed to be equal to the total undepleted flow at the confluence of the San Pedro and Gila Rivers. Using a network optimization model, MODSIM, Bazlen (1989) found that if all current agricultural water use in the San Pedro floodplain was removed, the total undepleted flow at the confluence was greater than 80,000 acre-feet/year (af/yr). However, under pre-developed conditions, it is likely that phreatophyte water use along the San Pedro River was higher than it currently is. When all agricultural water usage was replaced with phreatophyte water usage, the average undepleted outflow at the confluence was approximately 34,000 af/yr. Choosing a probable intermediate amount of phreatophyte replacement and water use under pre-developed conditions, Bazlen estimated the undepleted flow to be about 51,000 af/yr. The Arizona Department of Water Resources (ADWR) (1987) calculated the current average annual flow at the confluence as 41,010 af/yr. Thus, San Pedro Basin water users would have to "give up" the difference--10,000 af/yr--to fulfill maximum claims of total undepleted flow. This value was the basis for scenario formation used in this study.

Transmission losses are significant in arid and semi-arid streams (Lane, 1983). The distance along the Gila River from its confluence with the San Pedro River to the point at which the Gila River flows are diverted for the Gila River Indian Community (GRIC) is

100 miles. Based upon USGS flow records, it was assumed that transmission losses over this distance would amount to 1,000 acre-feet, and the GRIC would receive only 9000 af/yr of the additional 10,000 af/yr from the San Pedro River. These values formed the basis for the various scenarios.

5.2 Players, Player Objectives, and Objective Measures

5.2.1 Players

The proper identification of players is inherent to a successfully negotiated settlement. Any group which felt left out or treated unfairly by any settlement negotiated by others would likely contest that settlement if it had the power to do so, with the possible result that the negotiated settlement may no longer be realistic or implementable.

Participants in a negotiation should be those who have a stake in the outcome. This is obvious but difficult to apply, since stakeholders could be those directly and indirectly affected by the outcome. For this study, players were defined as those who are using water or have made a claim to water in the San Pedro Basin. It was assumed that there were no water users on the Gila River between the confluence of the Gila and San Pedro Rivers and the GRIC. The definition of the GRIC as a player is, of course, obvious.

The players within the San Pedro Basin were originally identified as all the major water users or claimants. Then-presiding Judge Goodfarb issued an order stating that the only claims to be considered within the adjudication are those to surface water and those claims to groundwater pumped from the floodplain aquifer immediately surrounding the river (the 50-90 rule, indicating those pumpers may interfere with surface flows and, therefore, surface water rights). Groundwater pumped from the much larger yet less transmissive regional aquifer which underlies the entire basin, while hydrologically linked to the San Pedro River, is not recognized legally as appropriable water and is not subject to the adjudication proceedings. Within the context of the Goodfarb order, the major water users within the confines of the San Pedro Basin which either divert surface water or pump from the floodplain aquifer are the agricultural water users and the few mining or industrial users within the Basin.

The agricultural water users can be further sub-classified as those within the Upper San Pedro Basin and those within the Lower San Pedro Basin. The distinction permitted the exploration of internal bargaining that could occur in a negotiated settlement. As the farmers within the San Pedro Basin were the major water users who would potentially be "giving up" water in either a negotiated or adjudicated settlement, the designation allowed for more flexibility and creativity in how this could be accomplished.

The mining operations in the lower part of the Basin are the only major industrial water users to be considered part of the adjudication. As discussed in Chapter 3, they were the claimants in the original "nucleus" lawsuit around which the General Adjudication was formed.

The federal government and the State of Arizona both filed claims to water within the San Pedro Basin. Due to their multiple constituencies, the federal and state interests in the dispute are multifaceted and diffuse. While critical to conflict resolution, the federal government's participation in any Indian water right conflict is always ambiguous because it has a trust responsibility to the Indians, while at the same time, has fostered the non-Indian growth and development dependent upon the water the Indians claim. The federal government has additional interests in the conflict including its proprietary responsibility as a land manager within the San Pedro basin, its political responsibility to constituent groups of interest, and its fiscal responsibility to taxpayers. The federal role in past settlements has been one of providing money (i.e., trust funds) and/or water (i.e., Central Arizona Project water). Whether this can or will continue is becoming less likely in the face of growing budgetary constraints. Still, the federal government is intimately involved in the conflict, and as previous settlements show, will be intimately involved in any solution.

The State of Arizona filed claims to water within the San Pedro Basin consisting mainly of surface water claims to stockponds. These were not considered for this study. In a recent report regarding stockponds for the adjudication proceedings, Young (1994) found that no measurable amount of water is lost from the river system through stockponds, resulting in the *de minimus* designation of less than 15 af/yr for stockpond usage (Office of the Special Master, June 1995). The State of Arizona was not considered to be a player in this study.

Municipal and domestic water use amounts to about 14% of all water consumption within the Upper San Pedro Basin (the largest single use) and about 3% in the Lower San Pedro Basin (the smallest use) (ADWR, 1987). The largest water use in the Upper San Pedro Basin occurs within the Sierra Vista/Fort Huachuca urban area. The city of Sierra Vista is located at the foot of the Huachuca Mountains and is supplied by deep wells tapping the regional aquifer, which is not in immediate hydrologic connection with the San

Pedro Basin (the smallest use) (ADWR, 1987). The largest water use in the Upper San Pedro Basin occurs within the Sierra Vista/Fort Huachuca urban area. The city of Sierra Vista is located at the foot of the Huachuca Mountains and is supplied by deep wells tapping the regional aquifer, which is not in immediate hydrologic connection with the San Pedro River. Although the transit times are long, the cone of depression caused by pumping will invariably have some effect upon the river flows. Currently, the water in the regional aquifer is not considered appropriable. For this study, the controversy will be ignored because of the uncertain legal status of the water in the regional aquifer.

Five players are included in the negotiated settlement framework for the San Pedro case study: (1) the GRIC, (2) the federal government, (3) the mines, (4) Upper San Pedro Basin agricultural water users, and (5) Lower San Pedro Basin agricultural water users.

5.2.2 Player Objectives and Objective Measures

5.2.2.1 GRIC

In an address on July 8, 1970, President Richard Nixon stated that federal Indian policies of the 1950s and 1960s had been detrimental to the Indians. He called for a new philosophy "determined by Indian acts and Indian decisions" (McGuire, 1990). The new federal objectives based on the President Nixon's statement, according to McGuire (1990), included bolstering the sovereignty of the tribes, and promoting Indian self sufficiency and cultural pluralism. These three objectives are independent and concurrent. In an analysis of federal executive, legislative, and judicial activity regarding Indians, McGuire concluded that the federal "intent" exists to attain those objectives in Indian policy although actual practice is often otherwise.

If it is assumed that, in its trust responsibility, the federal government has correctly discerned the objectives of its trustees, tribal sovereignty, self sufficiency, and cultural self determination can be assigned as Indian objectives. These objectives appear subsumed in a policy statement issued by the National Congress of American Indians (National Congress of American Indians, 1982).

McGuire (1990) suggested attributes by which objective attainment may be measured. These attributes were modified slightly for this study, dependent upon available information. Median family income was used as a measure of economic self sufficiency or development. Tribal sovereignty, the "maximization of wealth", was measured by total tribal income which could be affected by, for example, a development grant awarded to the GRIC in lieu of water. Cultural self determination, or the "full and free choice...allowed to present and future generations" (McGuire, 1990), is measured by land use mixes allowed by the award of San Pedro water, in accordance with the GRIC master plan.

5.2.2.2 The federal government

The federal government's objectives are several, complex, and often conflicting. For analytical purposes, the government's objectives are distilled to five: the three Indian objectives previously described, recognizing its trust responsibility; an environmental objective; and an objective of fiscal responsibility.

environmental concerns (i.e. Sierra Club, Audubon Society, Nature Conservancy), clearly establishing the government has a real environmental objective in this case.

The BLM has made an "instream claim" to flow within the San Pedro River within the conservation area boundaries; the claim must be addressed by the adjudication proceedings. Even a negotiated settlement must now recognize the federal responsibility to maintain a riparian habitat along the San Pedro River. The federal environmental objective is measured by increased riparian acreage (or decreased agricultural acreage assuming a 1:1 replacement ratio) along the San Pedro River.

It is interesting to note that the federal environmental objective in this instance may be practically consistent with its Indian objectives. The flow within the San Pedro may be protected by any award of water to the GRIC downstream.

Federal involvement in past negotiated settlements has included federal expenditures, which are sometimes substantial. The cost of implementation of the Ak-Chin Settlement Act, Southern Arizona Water Right Settlement Act, and Salt River Pima-Maricopa Settlements in Arizona alone is \$160 million, \$164 million, and \$60 million, respectively, measured in terms of water purchases, rehabilitation of existing Indian irrigation systems, development of new Indian irrigation and delivery system storage facilities, etc. (Simon, 1989). Throughout the West, Simon (1989) estimated the proposed federal commitment to existing Indian settlements was \$ 1.1 billion. The willingness of the government to fund settlements in the future is questionable due to budgetary concerns. Therefore, a federal expenditure objective is measured simply by the minimization of cost to the federal government.

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5.2.2.3 Mines

The main objective of the mines--indeed, of any business enterprise--is assumed to be profit maximization. Since profits are determined by external factors (the market) and internal factors (production costs), the measure for this objective was the minimization of production costs, as measured by the opportunity cost of water which the mines had to give up. The impact or control of market forces on profit maximization is outside the realm of this study. Since only a single objective was associated with the mines, there was no need to develop a preference weighted payoff. The payoff was simply the monetary value of the water they had to supply.

5.2.2.4 Upper and Lower San Pedro Basin agricultural water users

The objectives of the Upper and Lower San Pedro agricultural players are not easily discerned, because no single entity for representation exists within the Basin. Water and irrigation districts exist within the Basin, but they are small and localized. In several informal interviews with Basin residents for this study, the rural lifestyle of the basin was frequently mentioned as one of its attractive features. Presumably, some notion of open most of the basin's agriculture occurs), presumably in favor of increased riparian acreage and corresponding to the federal environmental objective.

Since farms and ranches, like the mines, are business enterprises, any changes that affect production costs, such as purchasing additional water rights, will affect profits. Thus, income maximization was also considered an agricultural objective, measured simply by farm income.

The relative weights among each player's objectives were derived from role-playing using MATS. A summary of player objectives, measures, and preference weights is found in Table 5.1.

5.3 Scenarios

Scenarios are the consequences of the individual action choices made by all players. Building upon the common elements of past settlements, combining player actions, and incorporating the circumstances particular to the study area led to the formation of 12 negotiated settlement scenarios. Several settlement concepts were explored. First, the amount of San Pedro water awarded to the GRIC could range from 0 to 9,000 af/yr (the undepleted flow at the upstream boundary of the GRIC). Second, imported water could be awarded to the Indians in place of the San Pedro water, up to the same undepleted flow constraint. The imported water would consist of Central Arizona Project (CAP) water, which could be delivered to the GRIC. Third, the costs of making this water available to the GRIC could be borne in various ways. The entire burden might be borne by the agricultural and industrial water users in the San Pedro Basin through loss

Table 5.1 Players, objectives, attributes, and standardized weights used for this study.

PLAYER	OBJECTIVE	ATTRIBUTE	MEASURED BY	STANDARD. WEIGHTS
GRIC	Self Sufficiency	Median Family Income	$	0.238
	Tribal Sovereignty	Tribal Income	$	0.382
	Self Determination	Land Use Mix	Ag. acres	0.190
			Indust. acres	0.190
Federal Government	Indian Self Sufficiency	GRIC Median Family Income	$	0.251
	Indian Tribal Sovereignty	GRIC Tribal Income	$	0.023
	Indian Self Determination	GRIC Land Use Mix	Ag. acres	0.100
			Indust. acres	0.100
	Environmental Enhancement	Riparian Acreage	% change in ag. acreage	0.263
	Fiscal Responsibility	Cost	$	0.263
Upper SP Ag.	Rural Lifestyle	Open Space	% change in ag. acreage	0.667
	Income	Cost	$	0.333
Lower SP Ag.	Rural Lifestyle	Open Space	% change in ag. acreage	0.781
	Income	Cost	$	0.219
Mines (lower SP)	Profit	Cost	$	1.000

of water rights, or it could be borne by the federal taxpayer. Fourth, the Indians could be awarded monetary payments or subsidies to permit them to develop new water. Again, the burden of doing so could be spread in various ways. Fifth, the GRIC could be awarded monetary payments in lieu of new water and be permitted to use these funds for economic development on the reservation. This burden could also be assigned in various ways. Sixth, water marketing was allowed between Upper and Lower San Pedro Basin agricultural water users in some strategies, in order to allow limited water supplies to flow to their highest uses, and thus minimize the costs of any award to the GRIC.

Possible outcomes of a failure to reach a negotiated settlement were also projected. Failure to negotiate successfully meant that the adjudication would proceed to its conclusion unassisted and that the court would then face the more limited options of awarding available San Pedro water to the claimants without the flexibility to consider imported water, to compensate the GRIC monetarily, or to specify cost-sharing arrangements. Since no one can foresee how much San Pedro water the court might award to the GRIC, three adjudication scenarios were defined and "best-guess" probabilities assigned to them. The possibilities ranged from a full award (9,000 ac-ft/yr) of San Pedro water to the GRIC, to no award of San Pedro water to the GRIC. The adjudication outcomes were assigned probabilities to account for the uncertainty surrounding them. These probabilities were somewhat arbitrary and subjective, and no attempt was made to analytically justify the assignment. It was reasoned, however, that an adjudicated outcome would most probably result in the GRIC "winning" at least some San Pedro water at the expense of users in the Basin. Therefore, a high probability was assigned to the outcome in which the GRIC won water, and a low probability was assigned to the adjudication outcome in which the GRIC won none of the San Pedro water. To further facilitate analysis, a single adjudicated payoff was defined as the probability weighted sum of the adjudication payoffs such that:

$$P_{adj} = \sum_{k=1}^{n} P_k \, p_k$$

where

P_{adj} = probability weighted adjudication payoff
P_k = payoff of adjudication scenario k (see Figure 4.5)
p_k = probability of adjudication scenario k.

A description of the 15 developed scenarios is given in Table 5.2. A condensed classification of scenarios is presented in Table 5.3.

5.4 Valuation

Bazlen (1989) calculated the marginal value product of water (MVP--a measure whereby water and money were equilibrated) within the San Pedro basin for several uses, and for the GRIC under conditions found in their master plan. Using the calculated MVPs, Bazlen created a matrix whereby various settlement options (including adjudication) were disaggregated into impacts accruing to the participants. The matrix was slightly modified and used to generate impacts of the 15 scenarios upon the five players identified for this case study. An example of the spreadsheet matrix is given in Appendix A. An example of how the values of water and money were decomposed into impacts for one player (Upper San Pedro agricultural water users - USPBAg) is shown in Table 5.4. These impacts, which in essence describe the scenario, were used in the determination of scenario payoffs.

Table 5.2 Detailed description of scenarios.

NEGOTIATION SCENARIOS

1. Full award to GRIC (10,000 af/yr)
   Fed. govt. pays dev. costs, compensates LSPBAg.
   Only LSPBAg users supply water.

2. Full award to GRIC (10,000 af/yr)
   Fed. govt. pays dev. costs
   SPB marketing occurs.

3. Full award to GRIC (10,000 af/yr)
   Fed. govt. pays dev. costs
   All SPB users supply water (no marketing).

4. Full award to GRIC (10,000 af/yr)
   Fed. govt. does not pay dev. costs
   All SPB users supply water (marketing occurs).

5. Full award to GRIC (10,000 af/yr)
   All SPB users supply water (no marketing).

6. Award to GRIC in CAP water (9,000 af/yr)
   Fed. govt. pays dev. and CAP costs.

7. Award to GRIC in CAP water (9,000 af/yr)
   Fed. govt. pays dev. costs
   All SPB users pay CAP costs.

8. Award to GRIC in CAP water (9,000 af/yr)
   Fed. govt. pays CAP costs only.

9. Award to GRIC in CAP water (9,000 af/yr)
   Fed. govt. does not pay dev. costs
   All SPB users pay CAP costs.

10. Award to GRIC in money
    Fed. govt. pays all costs.

11. Award to GRIC in money
    SPB users pay all costs.

12. Award to GRIC in money
    Fed. govt. pays 50% of cost
    SPB users pay 50% of cost.

ADJUDICATION SCENARIOS

13. GRIC wins water, pays court costs
    Fed. govt. pays court costs
    SPB users lose water and pay court costs.

14. GRIC does not win water, pays court costs
    Fed. govt. pays court costs
    SPB users keep water, pay court costs.

15. GRIC wins water, pays court costs
    Fed. govt. pays court costs
    SPB users lose water, pay court costs, marketing occurs.

NOTES

Abbreviations
GRIC = Gila River Indian Community
SPB = San Pedro Basin
LSPBAg = Lower San Pedro Basin Agriculture
CAP = Central Arizona Project

Marketing means that players USPBAg and MINES purchase LSPBAg water rights as suggested by Bazlen (1989). This is possible due to the differences between the marginal value product of water to these players.

Dev. costs (development costs) include the cost of irrigation canals, field preparation, etc.

Table 5.3 General description of scenarios (scenario numbers shown).

	GRIC demands water	GRIC demands money
Feds supply water (CAP)	6, 8[1]	
Feds supply money		10
SPB supplies water	4[2], 5	
SPB supplies money	9[1]	11
Feds supply money/SPB supplies money		12
Feds supply money/SPB supplies water	1, 2[2], 3	
Feds supply water/SPB supplies money	7[1]	
Feds supply water/SPB supplies water		

[1] CAP water
[2] SPB marketing occurs

5.5 Payoffs

For this exercise, scenarios and impacts were entered into the MATS program for each player. Each player was represented by a researcher who was considered knowledgeable about that particular player. These representatives, or role players, were asked to respond to developed scenarios (plans) using MATS to develop weights and scenario scores. Table 5.1 shows weights assigned each objective measure (factor).

Table 5.4 Sample calculations for Upper San Pedro Basin Agricultural (USPBAg) water users for Scenario 3.

I. Player Objectives and Measures (USPBAg)

A. Objective *Income* measured by attribute Cost ($).
B. Objective *Rural Lifestyle* measured by attribute % Change in Agricultural Acreage (ac).

II. Scenario Description (#3)

Full 9,000 acre-foot award to GRIC; the federal government pays development costs; San Pedro players supply water (10,000 acre-feet); San Pedro players compensated.

III. Sample Calculations
(based upon work by Bazlen (1989))

Given:
(1) USPBAg using 63% of the water players would have to provide;
(2) only 40% of the surface water in the Upper San Pedro reaches the confluence;
(3) the average marginal value product (MVP) of water to the USPBAg is $45.51 per acre-foot;
(4) the average application rate of water to agricultural land in the Upper San Pedro basin is 3.43 acre-feet per acre.

Therefore, the USPBAg portion of the 10,000 acre-foot liability is:

10,000 acre-feet x 63% or 6,300 acre-feet.

However, only 40% of the water reaches the confluence. In order to provide 6300 acre-feet at the confluence, the USPBAg users would have to provide:

6,300 acre-feet / 40% or 15,750 acre-feet.

Using the MVP of water, this translates to:

15,750 acre-feet x $45.51/acre-foot or $716,783.

This is the value of water the USPBAg users provide. This is the amount of compensation the federal government provides. Thus, the value for the *Income* attribute (Cost) is $716,783. Likewise, 15,750 acre-feet of water translates to:

15,750 acre-feet / 3.43 acre-feet water applied per acre or 4,592 acres.

This constitutes a loss of approximately 68% of the 6,800 acres currently under agricultural production. Thus, the value for the *Rural Lifestyle* attribute (% Change in Agricultural Acreage) is -68%.

5.6 Solutions

A matrix (Table 5.5) was developed to assess the individual and joint acceptability of each scenario. Scenarios are identified in column 1, and payoffs for each player for each scenario are found in columns 2 through 6. Each negotiation scenario (1-12) is compared to the expected payoff of the default adjudication scenario (the probability weighted sum of the three adjudication outcomes, 13-15). The expected payoff ("13-15 adj") is shown at the bottom of the matrix. Individual scenario acceptability per player is shown in columns 7 through 11. If the payoff for the negotiation scenario was greater than the expected payoff for the adjudication scenarios, then acceptability was indicated by "1". Unacceptability (negotiation payoff less than expected adjudication payoff) was indicated by "0". If a negotiation scenario was considered acceptable by all players, it was denoted by "1" in column 12. Column 12 shows the set of jointly acceptable negotiation scenarios, the solution set. Negotiation strategies 10, 11, and 12 were preferred to the adjudication outcome by all players. The common element of these scenarios is the award of money (approximately $700,000), not water, to the GRIC. Initially, this was surprising since one of the factors that motivates Indian participation in negotiated settlements is the lure of wet water as opposed to an adjudicated award of paper water. However, it can be reasoned that due to the apparently insignificant amount of water the scenario involved, 9,000 acre-feet per year in comparison to the nearly 1.5 million acre-feet per year the GRIC is claiming, the award of money is worth more to the GRIC than the water.

Table 5.5 Payoff/acceptability matrix for 51,000 af/yr liability.

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
SCENARIO	UTILITY PER PLAYER					INDIVIDUAL ACCEPTABILITY					JOINT ACCEPTABILITY
	I	II	III	IV	V	I	II	III	IV	V	
1.	0.67	0.39	0.99	0.24	0.00	1	0	1	0	1	0
2.	0.67	0.52	0.93	0.21	-0.25	1	0	1	0	0	0
3.	0.67	0.58	0.18	0.66	0.00	1	1	0	1	1	0
4.	0.60	0.56	0.93	0.21	-0.25	1	1	1	0	0	0
5.	0.60	0.62	0.18	0.66	0.00	1	1	0	1	1	0
6.	0.67	0.38	0.99	0.98	0.00	1	0	1	1	1	0
7.	0.67	0.52	0.92	0.94	-0.28	1	0	1	1	0	0
8.	0.60	0.42	0.99	0.98	0.00	1	0	1	1	1	0
9.	0.60	0.56	0.92	0.94	-0.28	1	1	1	1	0	0
10.	0.62	0.63	0.99	0.98	0.00	1	1	1	1	1	1
11.	0.62	0.70	0.96	0.96	-0.14	1	1	1	1	1	1
12.	0.62	0.67	0.97	0.97	-0.07	1	1	1	1	1	1
13.	0.58	0.60	0.18	0.66	-0.10						
14.	0.08	0.44	0.99	0.98	-0.10						
15.	0.39	0.43	0.93	0.10	-0.35						p(13) = 0.7
						1 = yes 0 = no					p(14) = 0.1
13-15 adj	0.53	0.55	0.40	0.57	-0.15						p(15) = 0.2
						Total acceptable:				3	

Player I - GRIC
Player II - Federal Government
Player III - Upper SP Basin Agriculture
Player IV - Lower SP Basin Agriculture
Player V - Mines

5.7 Summary

Case study inputs were applied to a framework for assessing the potential for negotiated settlement of Indian water rights conflicts. Using flow estimates from a hydrologic model and economic transformations, 12 negotiation scenarios and three adjudication scenarios were identified. Scenarios included awarding the full hydrologic entitlement of water in the San Pedro Basin to the GRIC (9,000 af/yr) in either San Pedro water or CAP water, and the San Pedro Basin water users employing various internal bargaining schemes to "give up" the water, with and without compensation by the federal government. Adjudication scenarios were also generated. Payoffs were calculated for each scenario using an interactive program, MATS, and expert input. Payoffs were assigned to each scenario and analyzed in a payoff/acceptability matrix. Using this matrix, individual and joint acceptability of negotiation scenarios could easily be assessed. It was shown that a set of jointly acceptable scenarios existed for the water right claims involving the San Pedro Basin. Further, each scenario within the jointly acceptable set has the characteristic of providing all players a higher payoff by negotiating than by adjudicating a conflict resolution.

CHAPTER 6

ANALYSIS OF UNCERTAINTY

6.1 Background

Indian water rights conflicts and the development of a methodology to address those conflicts have been described. Chapter 5 ended with application of the methodology to the conflict, and the description of a jointly acceptable conflict negotiation set--the nominal goal of this study. However, several questions remain unanswered. What if player preferences, let alone objectives, were not properly captured? How certain are the values (water amounts, for example) assigned to each player's payoff function? What is the impact of uncertainty regarding adjudication outcomes on the resultant jointly acceptable negotiation set? There is much uncertainty surrounding Indian water rights conflicts. This chapter will demonstrate how the impact of some of that uncertainty on the jointly acceptable negotiation set can be examined.

6.2 An Analysis of Individual Player Uncertainty

Recall from Chapter 5, player preferences, or weights, among objective measures were obtained by role-playing, not by eliciting the preferences of the actual parties to the conflict. The uncertainty surrounding the weights obtained is obvious. To ascertain the effect, if any, this uncertainty would have upon the set of acceptable negotiation scenarios, all weights within each player's payoff function were set equal, thereby simulating indifference. For example, the weights among the GRIC's four objective measures were each set to 0.25; the weights among the two objective measures for the Upper San Pedro agricultural players were set to 0.50 each. Additionally, an extreme weighting array was developed for the federal government to simulate an overwhelming concern for minimizing budgetary impact by assigning weights of 0.01 to five of its six objective measures; a weighting of 0.95 was assigned to the sixth objective measure of fiscal responsibility. The purpose of this weighting scheme was to ensure that some response to modified payoff functions could be detected in the final jointly acceptable negotiation set. All modified weighting schemes were entered into the MATS program, and modified player payoffs were recorded. Each player's modified payoff array was entered into the payoff/acceptability matrix individually while the remaining player payoff arrays remained unchanged. Finally, all indifference payoff arrays were entered simultaneously into the payoff/acceptability matrix. The results are shown in Table 6.1.

As in the original case (Table 5.5), three scenarios--10, 11, and 12--comprise the jointly acceptable negotiation set. These three scenarios appear to be relatively insensitive to weighting differences when assessed both individually and cumulatively. Scenarios 10, 11, and 12 all involve the award of money to the GRIC instead of water, again suggesting that a monetary award of approximately $700,000 is worth more to the GRIC than an award of 9,000 acre-feet of water, while the value of 10,000 acre-feet of water is worth more to the San Pedro players than $700,000. The acceptability of only

Table 6.1 Results of altering player weights on jointly acceptable negotiation set --10,000 acre-feet of water.

Weighting Scheme	No. of Acceptable Scenarios	Acceptable Scenarios
Original weights (Table 5.1)	3	10, 11, 12
GRIC weights equal	3	10, 11, 12
Federal weights equal	3	10, 11, 12
Upper SP ag. weights equal	3	10, 11, 12
Lower SP ag. weights equal	3	10, 11, 12
All player weights equal	3	10, 11, 12
Federal budget weight at 0.95	1	11

scenario 11--where the GRIC is paid money instead of water, but the San Pedro players are solely responsible for the payment of all costs--in the case when the federal weighting array is extremely partial to minimizing federal budgetary impact, seems reasonable under the specified conditions.

6.3 An Analysis of Uncertain Hydrologic Data

The 1985 data for both the GRIC and the San Pedro were used because they were the best available at that time. The major data sources were ADWR (1987) and Bazlen (1989), who asserted that the San Pedro players could only be liable for the difference in the amount of water at the confluence of the San Pedro with the Gila under current conditions (41,050 acre-feet), and the amount that would have reached the confluence under undepleted conditions (51,000 acre-feet)--hence, the 10,000 acre-feet value. In 1990, ADWR revised its flow estimates for the San Pedro River. ADWR estimated current average surface outflow to be 57,520 acre-feet per year. Eliminating all cultural water uses and assuming a resultant 12% increase in phreatophyte consumptive use, ADWR estimated the undepleted flow at the confluence to be 99,000 acre-feet per year. Using these figures, the San Pedro liability is increased approximately 41,000 acre-feet per year. The amount of water which would reach the GRIC is 40,000 acre-feet, assuming transmission losses amounting to 1000 acre-feet from the confluence to the GRIC. These revised figures provide an opportunity to assess the effect of new or modified information on the jointly acceptable negotiation set.

To begin, the revised undepleted flow estimate was entered into the Bazlen economic valuation matrix, and the resultant objective measure values (i.e., acres, income amounts, etc.) corresponding to each scenario for each player were recorded. These values were then entered into the MATS program to calculate player payoffs. While weights remained unchanged, it was necessary to adjust limits to the utility functions beyond those previously set to account for increases and decreases in impacts on objective attributes. Changing the limits of the utility function could alter resultant payoff values so that the effect of the revised flow figure would be undetectable. Therefore, the same new limits were applied to the original base case involving the 10,000 acre-feet to allow for adequate comparison. The change in the resultant payoffs per player is illustrated in Table 6.2a.

Table 6.2 Comparison of player payoffs at (a) 10,000 af/yr with original weights, and original and adjusted utility functions; and (b) payoffs at 10,000 af/yr and 99,000 af/yr with original weights and adjusted utility functions.

	GRIC			FEDERAL GOVERNMENT			UPPER SP AGRICULTURE			LOWER SP AGRICULTURE			MINES		
Scenario	Base	New	% change	Base	New	% change	Base	New	% change	Base	New	% change	Base	New	% change
1.	0.673	0.132	-80.4	0.392	0.279	-28.8	0.992	0.996	0.4	0.240	0.590	145.8	0.000	0.000	0.0
2.	0.673	0.132	-80.4	0.516	0.300	-41.9	0.926	0.969	4.6	0.207	0.580	180.2	-0.253	-0.253	0.0
3.	0.673	0.132	-80.4	0.580	0.429	-26.0	0.180	0.966	436.7	0.655	0.828	26.4	0.000	0.000	0.0
4.	0.602	0.111	-81.6	0.560	0.298	-46.8	0.926	0.969	4.6	0.207	0.580	180.2	-0.253	-0.253	0.0
5.	0.602	0.111	-81.6	0.624	0.427	-31.6	0.180	0.604	235.6	0.655	0.828	26.4	0.000	0.000	0.0
6.	0.673	0.132	-80.4	0.379	0.277	-26.9	0.992	0.996	0.4	0.978	0.997	1.9	0.000	0.000	0.0
7.	0.673	0.132	-80.4	0.516	0.300	-41.9	0.919	0.966	5.1	0.942	0.985	4.6	-0.281	-0.281	0.0
8.	0.602	0.111	-81.6	0.422	0.275	-34.8	0.992	0.996	0.4	0.978	0.997	1.9	0.000	0.000	0.0
9.	0.602	0.111	-81.6	0.560	0.298	-46.8	0.919	0.966	5.1	0.942	0.985	4.6	-0.281	-0.281	0.0
10.	0.615	0.208	-66.2	0.634	0.369	-41.8	0.992	0.996	0.4	0.978	0.997	1.9	0.000	0.000	0.0
11.	0.615	0.208	-66.2	0.702	0.381	-45.7	0.955	0.981	2.7	0.960	0.991	3.2	-0.140	-0.140	0.0
12.	0.615	0.208	-66.2	0.668	0.375	-43.9	0.974	0.989	1.5	0.969	0.994	2.6	-0.070	-0.070	0.0
13.	0.575	0.107	-81.4	0.596	0.422	-29.2	0.179	0.603	236.9	0.655	0.828	26.4	-0.100	-0.100	0.0
14.	0.077	0.020	-74.0	0.444	0.280	-36.9	0.991	0.996	0.5	0.978	0.996	1.8	-0.100	-0.100	0.0
15.	0.385	0.071	-81.6	0.432	0.274	-36.6	0.926	0.969	4.6	0.103	0.547	431.1	-0.353	-0.353	0.0
13-15 adj	0.525	0.098	-81.3	0.548	0.378	-31.0	0.401	0.701	74.7	0.565	0.773	36.7	-0.153	-0.153	0.0

(b)

	GRIC			FEDERAL GOVERNMENT			UPPER SP AGRICULTURE			LOWER SP AGRICULTURE			MINES		
Scenario	New	99k af	% change	New	99k af	% change	New	99k af	% change	New	99k af	% change	New	99k af	% change
1.	0.132	0.706	434.8	0.279	0.283	1.4	0.996	0.996	0.0	0.590	0.216	-63.4	0.000	0.000	0.0
2.	0.132	0.706	434.8	0.300	0.384	28.0	0.969	0.863	-10.9	0.580	0.164	-71.7	-0.253	-0.124	-51.0
3.	0.132	0.706	434.8	0.429	0.647	50.8	0.966	0.006	-99.4	0.828	0.186	-77.5	0.000	0.000	0.0
4.	0.111	0.676	509.0	0.298	0.389	30.5	0.969	0.863	-10.9	0.580	0.164	-71.7	-0.253	-0.124	-51.0
5.	0.111	0.676	509.0	0.427	0.652	52.7	0.604	0.006	-99.0	0.828	0.186	-77.5	0.000	0.000	0.0
6.	0.132	0.706	434.8	0.277	0.262	-5.4	0.996	0.996	0.0	0.997	0.997	0.0	0.000	0.000	0.0
7.	0.132	0.706	434.8	0.300	0.384	28.0	0.966	0.835	-13.6	0.985	0.935	-5.1	-0.281	-0.150	-46.7
8.	0.111	0.676	509.0	0.275	0.267	-2.9	0.996	0.996	0.0	0.997	0.997	0.0	0.000	0.000	0.0
9.	0.111	0.676	509.0	0.298	0.389	30.5	0.966	0.835	-13.6	0.985	0.935	-5.1	-0.281	-0.150	-46.7
10.	0.208	0.520	150.0	0.369	0.521	41.2	0.996	0.996	0.0	0.997	0.997	0.0	0.000	0.000	0.0
11.	0.208	0.520	150.0	0.381	0.582	52.8	0.981	0.867	-11.6	0.991	0.966	-2.5	-0.140	-0.074	-46.8
12.	0.208	0.520	150.0	0.375	0.551	46.9	0.989	0.956	-3.3	0.994	0.981	-1.3	-0.070	-0.037	-46.8
13.	0.107	0.672	528.0	0.422	0.648	53.6	0.603	0.006	-99.0	0.828	0.186	-77.5	-0.100	-0.010	-90.0
14.	0.020	0.180	800.0	0.280	0.309	10.4	0.996	0.996	0.0	0.996	0.996	0.0	-0.100	-0.010	-90.0
15.	0.071	0.484	581.7	0.274	0.285	4.0	0.969	0.863	-10.9	0.547	0.004	-99.3	-0.353	-0.134	-62.0
13-15 adj	0.098	0.631	542.4	0.378	0.542	43.2	0.701	0.271	-61.4	0.773	0.226	-70.8	-0.153	-0.035	-76.9

Table 6.2 Comparison of player payoffs at (a) 10,000 af/yr with original weights, and original and adjusted utility functions; and (b) payoffs at 10,000 af/yr and 99,000 af/yr with original weights and adjusted utility functions.

	GRIC			FEDERAL GOVERNMENT			UPPER SP AGRICULTURE			LOWER SP AGRICULTURE			MINES		
Scenario	Base	New	% change	Base	New	% change	Base	New	% change	Base	New	% change	Base	New	% change
1.	0.673	0.132	-80.4	0.392	0.279	-28.8	0.992	0.996	0.4	0.240	0.590	145.8	0.000	0.000	0.0
2.	0.673	0.132	-80.4	0.516	0.300	-41.9	0.926	0.969	4.6	0.207	0.580	180.2	-0.253	-0.253	0.0
3.	0.673	0.132	-80.4	0.580	0.429	-26.0	0.180	0.966	436.7	0.655	0.828	26.4	0.000	0.000	0.0
4.	0.602	0.111	-81.6	0.560	0.298	-46.8	0.926	0.969	4.6	0.207	0.580	180.2	-0.253	-0.253	0.0
5.	0.602	0.111	-81.6	0.624	0.427	-31.6	0.180	0.604	235.6	0.655	0.828	26.4	0.000	0.000	0.0
6.	0.673	0.132	-80.4	0.379	0.277	-26.9	0.992	0.996	0.4	0.978	0.997	1.9	0.000	0.000	0.0
7.	0.673	0.132	-80.4	0.516	0.300	-41.9	0.919	0.966	5.1	0.942	0.985	4.6	-0.281	-0.281	0.0
8.	0.602	0.111	-81.6	0.422	0.275	-34.8	0.992	0.996	0.4	0.978	0.997	1.9	0.000	0.000	0.0
9.	0.602	0.111	-81.6	0.560	0.298	-46.8	0.919	0.966	5.1	0.942	0.985	4.6	-0.281	-0.281	0.0
10.	0.615	0.208	-66.2	0.634	0.369	-41.8	0.992	0.996	0.4	0.978	0.997	1.9	0.000	0.000	0.0
11.	0.615	0.208	-66.2	0.702	0.381	-45.7	0.955	0.981	2.7	0.960	0.991	3.2	-0.140	-0.140	0.0
12.	0.615	0.208	-66.2	0.668	0.375	-43.9	0.974	0.989	1.5	0.969	0.994	2.6	-0.070	-0.070	0.0
13.	0.575	0.107	-81.4	0.596	0.422	-29.2	0.179	0.603	236.9	0.655	0.828	26.4	-0.100	-0.100	0.0
14.	0.077	0.020	-74.0	0.444	0.280	-36.9	0.991	0.996	0.5	0.978	0.996	1.8	-0.100	-0.100	0.0
15.	0.385	0.071	-81.6	0.432	0.274	-36.6	0.926	0.969	4.6	0.103	0.547	431.1	-0.353	-0.353	0.0
13-15 adj	0.525	0.098	-81.3	0.548	0.378	-31.0	0.401	0.701	74.7	0.565	0.773	36.7	-0.153	-0.153	0.0

(b)

	GRIC			FEDERAL GOVERNMENT			UPPER SP AGRICULTURE			LOWER SP AGRICULTURE			MINES		
Scenario	New	99k af	% change	New	99k af	% change	New	99k af	% change	New	99k af	% change	New	99k af	% change
1.	0.132	0.706	434.8	0.279	0.283	1.4	0.996	0.996	0.0	0.590	0.216	-63.4	0.000	0.000	0.0
2.	0.132	0.706	434.8	0.300	0.384	28.0	0.969	0.863	-10.9	0.580	0.164	-71.7	-0.253	-0.124	-51.0
3.	0.132	0.706	434.8	0.429	0.647	50.8	0.966	0.006	-99.4	0.828	0.186	-77.5	0.000	0.000	0.0
4.	0.111	0.676	509.0	0.298	0.389	30.5	0.969	0.863	-10.9	0.580	0.164	-71.7	-0.253	-0.124	-51.0
5.	0.111	0.676	509.0	0.427	0.652	52.7	0.604	0.006	-99.0	0.828	0.186	-77.5	0.000	0.000	0.0
6.	0.132	0.706	434.8	0.277	0.262	-5.4	0.996	0.996	0.0	0.997	0.997	0.0	0.000	0.000	0.0
7.	0.132	0.706	434.8	0.300	0.384	28.0	0.966	0.835	-13.6	0.985	0.935	-5.1	-0.281	-0.150	-46.7
8.	0.111	0.676	509.0	0.275	0.267	-2.9	0.996	0.996	0.0	0.997	0.997	0.0	0.000	0.000	0.0
9.	0.111	0.676	509.0	0.298	0.389	30.5	0.966	0.835	-13.6	0.985	0.935	-5.1	-0.281	-0.150	-46.7
10.	0.208	0.520	150.0	0.369	0.521	41.2	0.996	0.996	0.0	0.997	0.997	0.0	0.000	0.000	0.0
11.	0.208	0.520	150.0	0.381	0.582	52.8	0.981	0.867	-11.6	0.991	0.966	-2.5	-0.140	-0.074	-46.8
12.	0.208	0.520	150.0	0.375	0.551	46.9	0.989	0.956	-3.3	0.994	0.981	-1.3	-0.070	-0.037	-46.8
13.	0.107	0.672	528.0	0.422	0.648	53.6	0.603	0.006	-99.0	0.828	0.186	-77.5	-0.100	-0.010	-90.0
14.	0.020	0.180	800.0	0.280	0.309	10.4	0.996	0.996	0.0	0.996	0.996	0.0	-0.100	-0.010	-90.0
15.	0.071	0.484	581.7	0.274	0.285	4.0	0.969	0.863	-10.9	0.547	0.004	-99.3	-0.353	-0.134	-62.0
13-15 adj	0.098	0.631	542.4	0.378	0.542	43.2	0.701	0.271	-61.4	0.773	0.226	-70.8	-0.153	-0.035	-76.9

Table 6.2 Comparison of player payoffs at (a) 10,000 af/yr with original weights, and original and adjusted utility functions; and (b) papyoffs at 10,000 af/yr and 99,000 af/yr with original weights and adjusted utility functions.

	GRIC			FEDERAL GOVERNMENT			UPPER SP AGRICULTURE			LOWER SP AGRICULTURE			MINES		
Scenario	Base	New	% change	Base	New	% change	Base	New	% change	Base	New	% change	Base	New	% change
1.	0.673	0.132	-80.4	0.392	0.279	-28.8	0.992	0.996	0.4	0.240	0.590	145.8	0.000	0.000	0.0
2.	0.673	0.132	-80.4	0.516	0.300	-41.9	0.926	0.969	4.6	0.207	0.580	180.2	-0.253	-0.253	0.0
3.	0.673	0.132	-80.4	0.580	0.429	-26.0	0.180	0.966	436.7	0.655	0.828	26.4	0.000	0.000	0.0
4.	0.602	0.111	-81.6	0.560	0.298	-46.8	0.926	0.969	4.6	0.207	0.580	180.2	-0.253	-0.253	0.0
5.	0.602	0.111	-81.6	0.624	0.427	-31.6	0.180	0.604	235.6	0.655	0.828	26.4	0.000	0.000	0.0
6.	0.673	0.132	-80.4	0.379	0.277	-26.9	0.992	0.996	0.4	0.978	0.997	1.9	0.000	0.000	0.0
7.	0.673	0.132	-80.4	0.516	0.300	-41.9	0.919	0.966	5.1	0.942	0.985	4.6	-0.281	-0.281	0.0
8.	0.602	0.111	-81.6	0.422	0.275	-34.8	0.992	0.996	0.4	0.978	0.997	1.9	0.000	0.000	0.0
9.	0.602	0.111	-81.6	0.560	0.298	-46.8	0.919	0.966	5.1	0.942	0.985	4.6	-0.281	-0.281	0.0
10.	0.615	0.208	-66.2	0.634	0.369	-41.8	0.992	0.996	0.4	0.978	0.997	1.9	0.000	0.000	0.0
11.	0.615	0.208	-66.2	0.702	0.381	-45.7	0.955	0.981	2.7	0.960	0.991	3.2	-0.140	-0.140	0.0
12.	0.615	0.208	-66.2	0.668	0.375	-43.9	0.974	0.989	1.5	0.969	0.994	2.6	-0.070	-0.070	0.0
13.	0.575	0.107	-81.4	0.596	0.422	-29.2	0.179	0.603	236.9	0.655	0.828	26.4	-0.100	-0.100	0.0
14.	0.077	0.020	-74.0	0.444	0.280	-36.9	0.991	0.996	0.5	0.978	0.996	1.8	-0.100	-0.100	0.0
15.	0.385	0.071	-81.6	0.432	0.274	-36.6	0.926	0.969	4.6	0.103	0.547	431.1	-0.353	-0.353	0.0
13-15 adj	0.525	0.098	-81.3	0.548	0.378	-31.0	0.401	0.701	74.7	0.565	0.773	36.7	-0.153	-0.153	0.0

(b)

	GRIC			FEDERAL GOVERNMENT			UPPER SP AGRICULTURE			LOWER SP AGRICULTURE			MINES		
Scenario	New	99k af	% change	New	99k af	% change	New	99k af	% change	New	99k af	% change	New	99k af	% change
1.	0.132	0.706	434.8	0.279	0.283	1.4	0.996	0.996	0.0	0.590	0.216	-63.4	0.000	0.000	0.0
2.	0.132	0.706	434.8	0.300	0.384	28.0	0.969	0.863	-10.9	0.580	0.164	-71.7	-0.253	-0.124	-51.0
3.	0.132	0.706	434.8	0.429	0.647	50.8	0.966	0.006	-99.4	0.828	0.186	-77.5	0.000	0.000	0.0
4.	0.111	0.676	509.0	0.298	0.389	30.5	0.969	0.863	-10.9	0.580	0.164	-71.7	-0.253	-0.124	-51.0
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7.	0.132	0.706	434.8	0.300	0.384	28.0	0.966	0.835	-13.6	0.985	0.935	-5.1	-0.281	-0.150	-46.7
8.	0.111	0.676	509.0	0.275	0.267	-2.9	0.996	0.996	0.0	0.997	0.997	0.0	0.000	0.000	0.0
9.	0.111	0.676	509.0	0.298	0.389	30.5	0.966	0.835	-13.6	0.985	0.935	-5.1	-0.281	-0.150	-46.7
10.	0.208	0.520	150.0	0.369	0.521	41.2	0.996	0.996	0.0	0.997	0.997	0.0	0.000	0.000	0.0
11.	0.208	0.520	150.0	0.381	0.582	52.8	0.981	0.867	-11.6	0.991	0.966	-2.5	-0.140	-0.074	-46.8
12.	0.208	0.520	150.0	0.375	0.551	46.9	0.989	0.956	-3.3	0.994	0.981	-1.3	-0.070	-0.037	-46.8
13.	0.107	0.672	528.0	0.422	0.648	53.6	0.603	0.006	-99.0	0.828	0.186	-77.5	-0.100	-0.010	-90.0
14.	0.020	0.180	800.0	0.280	0.309	10.4	0.996	0.996	0.0	0.996	0.996	0.0	-0.100	-0.010	-90.0
15.	0.071	0.484	581.7	0.274	0.285	4.0	0.969	0.863	-10.9	0.547	0.004	-99.3	-0.353	-0.134	-62.0
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Scenario	Base	New	% change	Base	New	% change	Base	New	% change	Base	New	% change	Base	New	% change
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3.	0.673	0.132	-80.4	0.580	0.429	-26.0	0.180	0.966	436.7	0.655	0.828	26.4	0.000	0.000	0.0
4.	0.602	0.111	-81.6	0.560	0.298	-46.8	0.926	0.969	4.6	0.207	0.580	180.2	-0.253	-0.253	0.0
5.	0.602	0.111	-81.6	0.624	0.427	-31.6	0.180	0.604	235.6	0.655	0.828	26.4	0.000	0.000	0.0
6.	0.673	0.132	-80.4	0.379	0.277	-26.9	0.992	0.996	0.4	0.978	0.997	1.9	0.000	0.000	0.0
7.	0.673	0.132	-80.4	0.516	0.300	-41.9	0.919	0.966	5.1	0.942	0.985	4.6	-0.281	-0.281	0.0
8.	0.602	0.111	-81.6	0.422	0.275	-34.8	0.992	0.996	0.4	0.978	0.997	1.9	0.000	0.000	0.0
9.	0.602	0.111	-81.6	0.560	0.298	-46.8	0.919	0.966	5.1	0.942	0.985	4.6	-0.281	-0.281	0.0
10.	0.615	0.208	-66.2	0.634	0.369	-41.8	0.992	0.996	0.4	0.978	0.997	1.9	0.000	0.000	0.0
11.	0.615	0.208	-66.2	0.702	0.381	-45.7	0.955	0.981	2.7	0.960	0.991	3.2	-0.140	-0.140	0.0
12.	0.615	0.208	-66.2	0.668	0.375	-43.9	0.974	0.989	1.5	0.969	0.994	2.6	-0.070	-0.070	0.0
13.	0.575	0.107	-81.4	0.596	0.422	-29.2	0.179	0.603	236.9	0.655	0.828	26.4	-0.100	-0.100	0.0
14.	0.077	0.020	-74.0	0.444	0.280	-36.9	0.991	0.996	0.5	0.978	0.996	1.8	-0.100	-0.100	0.0
15.	0.385	0.071	-81.6	0.432	0.274	-36.6	0.926	0.969	4.6	0.103	0.547	431.1	-0.353	-0.353	0.0
13-15 adj	0.525	0.098	-81.3	0.548	0.378	-31.0	0.401	0.701	74.7	0.565	0.773	36.7	-0.153	-0.153	0.0

(b)

	GRIC			FEDERAL GOVERNMENT			UPPER SP AGRICULTURE			LOWER SP AGRICULTURE			MINES		
Scenario	New	99k af	% change	New	99k af	% change	New	99k af	% change	New	99k af	% change	New	99k af	% change
1.	0.132	0.706	434.8	0.279	0.283	1.4	0.996	0.996	0.0	0.590	0.216	-63.4	0.000	0.000	0.0
2.	0.132	0.706	434.8	0.300	0.384	28.0	0.969	0.863	-10.9	0.580	0.164	-71.7	-0.253	-0.124	-51.0
3.	0.132	0.706	434.8	0.429	0.647	50.8	0.966	0.006	-99.4	0.828	0.186	-77.5	0.000	0.000	0.0
4.	0.111	0.676	509.0	0.298	0.389	30.5	0.969	0.863	-10.9	0.580	0.164	-71.7	-0.253	-0.124	-51.0
5.	0.111	0.676	509.0	0.427	0.652	52.7	0.604	0.006	-99.0	0.828	0.186	-77.5	0.000	0.000	0.0
6.	0.132	0.706	434.8	0.277	0.262	-5.4	0.996	0.996	0.0	0.997	0.997	0.0	0.000	0.000	0.0
7.	0.132	0.706	434.8	0.300	0.384	28.0	0.966	0.835	-13.6	0.985	0.935	-5.1	-0.281	-0.150	-46.7
8.	0.111	0.676	509.0	0.275	0.267	-2.9	0.996	0.996	0.0	0.997	0.997	0.0	0.000	0.000	0.0
9.	0.111	0.676	509.0	0.298	0.389	30.5	0.966	0.835	-13.6	0.985	0.935	-5.1	-0.281	-0.150	-46.7
10.	0.208	0.520	150.0	0.369	0.521	41.2	0.996	0.996	0.0	0.997	0.997	0.0	0.000	0.000	0.0
11.	0.208	0.520	150.0	0.381	0.582	52.8	0.981	0.867	-11.6	0.991	0.966	-2.5	-0.140	-0.074	-46.8
12.	0.208	0.520	150.0	0.375	0.551	46.9	0.989	0.956	-3.3	0.994	0.981	-1.3	-0.070	-0.037	-46.8
13.	0.107	0.672	528.0	0.422	0.648	53.6	0.603	0.006	-99.0	0.828	0.186	-77.5	-0.100	-0.010	-90.0
14.	0.020	0.180	800.0	0.280	0.309	10.4	0.996	0.996	0.0	0.996	0.996	0.0	-0.100	-0.010	-90.0
15.	0.071	0.484	581.7	0.274	0.285	4.0	0.969	0.863	-10.9	0.547	0.004	-99.3	-0.353	-0.134	-62.0
13-15 adj	0.098	0.631	542.4	0.378	0.542	43.2	0.701	0.271	-61.4	0.773	0.226	-70.8	-0.153	-0.035	-76.9

Table 6.2 Comparison of player payoffs at (a) 10,000 af/yr with original weights, and original and adjusted utility functions; and (b) payoffs at 10,000 af/yr and 99,000 af/yr with original weights and adjusted utility functions.

	GRIC			FEDERAL GOVERNMENT			UPPER SP AGRICULTURE			LOWER SP AGRICULTURE			MINES		
Scenario	Base	New	% change	Base	New	% change	Base	New	% change	Base	New	% change	Base	New	% change
1.	0.673	0.132	-80.4	0.392	0.279	-28.8	0.992	0.996	0.4	0.240	0.590	145.8	0.000	0.000	0.0
2.	0.673	0.132	-80.4	0.516	0.300	-41.9	0.926	0.969	4.6	0.207	0.580	180.2	-0.253	-0.253	0.0
3.	0.673	0.132	-80.4	0.580	0.429	-26.0	0.180	0.966	436.7	0.655	0.828	26.4	0.000	0.000	0.0
4.	0.602	0.111	-81.6	0.560	0.298	-46.8	0.926	0.969	4.6	0.207	0.580	180.2	-0.253	-0.253	0.0
5.	0.602	0.111	-81.6	0.624	0.427	-31.6	0.180	0.604	235.6	0.655	0.828	26.4	0.000	0.000	0.0
6.	0.673	0.132	-80.4	0.379	0.277	-26.9	0.992	0.996	0.4	0.978	0.997	1.9	0.000	0.000	0.0
7.	0.673	0.132	-80.4	0.516	0.300	-41.9	0.919	0.966	5.1	0.942	0.985	4.6	-0.281	-0.281	0.0
8.	0.602	0.111	-81.6	0.422	0.275	-34.8	0.992	0.996	0.4	0.978	0.997	1.9	0.000	0.000	0.0
9.	0.602	0.111	-81.6	0.560	0.298	-46.8	0.919	0.966	5.1	0.942	0.985	4.6	-0.281	-0.281	0.0
10.	0.615	0.208	-66.2	0.634	0.369	-41.8	0.992	0.996	0.4	0.978	0.997	1.9	0.000	0.000	0.0
11.	0.615	0.208	-66.2	0.702	0.381	-45.7	0.955	0.981	2.7	0.960	0.991	3.2	-0.140	-0.140	0.0
12.	0.615	0.208	-66.2	0.668	0.375	-43.9	0.974	0.989	1.5	0.969	0.994	2.6	-0.070	-0.070	0.0
13.	0.575	0.107	-81.4	0.596	0.422	-29.2	0.179	0.603	236.9	0.655	0.828	26.4	-0.100	-0.100	0.0
14.	0.077	0.020	-74.0	0.444	0.280	-36.9	0.991	0.996	0.5	0.978	0.996	1.8	-0.100	-0.100	0.0
15.	0.385	0.071	-81.6	0.432	0.274	-36.6	0.926	0.969	4.6	0.103	0.547	431.1	-0.353	-0.353	0.0
13-15 adj	0.525	0.098	-81.3	0.548	0.378	-31.0	0.401	0.701	74.7	0.565	0.773	36.7	-0.153	-0.153	0.0

(b)

	GRIC			FEDERAL GOVERNMENT			UPPER SP AGRICULTURE			LOWER SP AGRICULTURE			MINES		
Scenario	New	99k af	% change	New	99k af	% change	New	99k af	% change	New	99k af	% change	New	99k af	% change
1.	0.132	0.706	434.8	0.279	0.283	1.4	0.996	0.996	0.0	0.590	0.216	-63.4	0.000	0.000	0.0
2.	0.132	0.706	434.8	0.300	0.384	28.0	0.969	0.863	-10.9	0.580	0.164	-71.7	-0.253	-0.124	-51.0
3.	0.132	0.706	434.8	0.429	0.647	50.8	0.966	0.006	-99.4	0.828	0.186	-77.5	0.000	0.000	0.0
4.	0.111	0.676	509.0	0.298	0.389	30.5	0.969	0.863	-10.9	0.580	0.164	-71.7	-0.253	-0.124	-51.0
5.	0.111	0.676	509.0	0.427	0.652	52.7	0.604	0.006	-99.0	0.828	0.186	-77.5	0.000	0.000	0.0
6.	0.132	0.706	434.8	0.277	0.262	-5.4	0.996	0.996	0.0	0.997	0.997	0.0	0.000	0.000	0.0
7.	0.132	0.706	434.8	0.300	0.384	28.0	0.966	0.835	-13.6	0.985	0.935	-5.1	-0.281	-0.150	-46.7
8.	0.111	0.676	509.0	0.275	0.267	-2.9	0.996	0.996	0.0	0.997	0.997	0.0	0.000	0.000	0.0
9.	0.111	0.676	509.0	0.298	0.389	30.5	0.966	0.835	-13.6	0.985	0.935	-5.1	-0.281	-0.150	-46.7
10.	0.208	0.520	150.0	0.369	0.521	41.2	0.996	0.996	0.0	0.997	0.997	0.0	0.000	0.000	0.0
11.	0.208	0.520	150.0	0.381	0.582	52.8	0.981	0.867	-11.6	0.991	0.966	-2.5	-0.140	-0.074	-46.8
12.	0.208	0.520	150.0	0.375	0.551	46.9	0.989	0.956	-3.3	0.994	0.981	-1.3	-0.070	-0.037	-46.8
13.	0.107	0.672	528.0	0.422	0.648	53.6	0.603	0.006	-99.0	0.828	0.186	-77.5	-0.100	-0.010	-90.0
14.	0.020	0.180	800.0	0.280	0.309	10.4	0.996	0.996	0.0	0.996	0.996	0.0	-0.100	-0.010	-90.0
15.	0.071	0.484	581.7	0.274	0.285	4.0	0.969	0.863	-10.9	0.547	0.004	-99.3	-0.353	-0.134	-62.0
13-15 adj	0.098	0.631	542.4	0.378	0.542	43.2	0.701	0.271	-61.4	0.773	0.226	-70.8	-0.153	-0.035	-76.9

Generally, payoffs for the GRIC and the federal government--the "demanders" of water--decreased with expanded limits. This was to be expected since the value of 9,000 acre-feet of water and its equivalents in money or acreage was less than could be realized from 40,000 acre-feet of water. The payoffs for the San Pedro players--the "suppliers" of money or water--is reversed, sometimes drastically. Again, this is to be expected since supplying 10,000 acre-feet of water or its monetary equivalent is more desirable than supplying 41,000 acre-feet of water or its monetary equivalent. For completeness, the same weighting schemes as described in Section 6.2 were applied using the revised payoff values, with results shown in Table 6.3

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Table 6.3 Results of altering player weights on jointly acceptable negotiation set --10,000 acre-feet of water, adjusted utility functions.

Weighting Scheme	**No. of Acceptable Scenarios**	**Acceptable Scenarios**
Original weights (Table 5.1)	2	3, 11
GRIC weights equal	2	3, 11
Federal weights equal	4	3, 10, 11, 12
Upper SP ag. weights equal	1	11
Lower SP ag. weights equal	2	3, 11
All player weights equal	3	10, 11, 12
Federal budget weight at 0.95	1	11

The set of acceptable scenarios appeared slightly more sensitive to player weights, due to the expanded range of potential awards and costs. Scenario 3 now appeared in the negotiation set, where GRIC received 9,000 acre-feet of water, the federal government provided a development grant, and no marketing occurred between Upper and Lower San Pedro basin water users. The distinguishing characteristic of this scenario among similar scenarios (1 and 2) was the minimization of agricultural acreage lost within the Lower San Pedro Basin due to loss of water rights. Scenario 11--award to the GRIC in money, with the San Pedro water users paying all costs--consistently appeared within the acceptable negotiation set, again seeming to suggest a willingness to substitute money for water. The joint appearance of these two relatively dissimilar scenarios in the acceptable set under the same player weighting schemes indicated that the players may be responding to potential utilities as simulated by changes to the utility function. For example, referring to Figure 4.4 and assuming a negative utility function (b), a value of 49 (loss in percent of agricultural acreage) would result in a low utility on a scale of 0 to 49. The same value would result in a higher utility on a scale of 0 to 100.

Once the utility functions were adjusted for expanded ranges, resultant payoffs due to the 99,000 acre-feet water liability were compared, as shown in Table 6.2b. The payoff to the GRIC increased significantly, whether measured in 99,000 acre-feet of water or its monetary or acreage equivalents. Payoffs generally decreased to the San

Pedro players under scenarios where they alone bore the burden of full liability. The changes to the federal payoffs remained relatively unchanged.

The critical question, however, was how the new water value affected the joint acceptable negotiation set. As was done previously, the adjusted payoffs were entered into the payoff/acceptability matrix, and the weighting analysis was carried out. The results are give in Table 6.4.

Table 6.4 Results of altering player weights on jointly acceptable negotiation set --99,000 acre-foot liability, adjusted utility functions.

Weighting Scheme	No. of Acceptable Scenarios	Acceptable Scenarios
Original weights (Table 5.1)	0	0
GRIC weights equal	0	0
Federal weights equal	0	0
Upper SP ag. weights equal	0	0
Lower SP ag. weights equal	0	0
All player weights equal	1	5

With only one exception, no negotiation scenarios were jointly acceptable to all players under the assumption that total undepleted flow of the San Pedro equals 99,000 acre-feet per year--adjudication was the resultant resolution scenario. Several scenarios were individually acceptable (see columns 7 through 11 in Table 6.5), although only four scenarios appeared acceptable to the federal government. Examination of the

Table 6.5 Payoff/acceptability matrix for 99,000 acre-foot liability, original weights.

1	2	3	4	5	6	7	8	9	10	11	12	
SCENARIO	UTILITY PER PLAYER					INDIVIDUAL ACCEPTABILITY					JOINT ACCEPTABILITY	
	I	II	III	IV	V	I	II	III	IV	V		
1.	0.71	0.28	1.00	0.22	0.00	1	0	1	0	1	0	
2.	0.71	0.38	0.86	0.16	-0.12	1	0	1	0	0	0	
3.	0.71	0.65	0.01	0.19	0.00	1	1	0	0	1	0	
4.	0.68	0.39	0.86	0.16	-0.12	1	0	1	0	0	0	
5.	0.68	0.65	0.01	0.19	0.00	1	1	0	0	1	0	
6.	0.71	0.26	1.00	1.00	0.00	1	0	1	1	1	0	
7.	0.71	0.38	0.84	0.94	-0.15	1	0	1	1	0	0	
8.	0.68	0.27	1.00	1.00	0.00	1	0	1	1	1	0	
9.	0.68	0.39	0.84	0.94	-0.15	1	0	1	1	0	0	
10.	0.52	0.52	1.00	1.00	0.00	0	0	1	1	1	0	
11.	0.52	0.58	0.87	0.97	-0.07	0	1	1	1	0	0	
12.	0.52	0.55	0.96	0.98	-0.04	0	1	1	1	0	0	
13.	0.67	0.65	0.01	0.19	-0.01							
14.	0.18	0.31	1.00	1.00	-0.01							
15.	0.48	0.29	0.86	0.00	-0.13						p(13) =	0.7
						1 = yes 0 = no					p(14) =	0.1
13-15 adj	0.63	0.54	0.27	0.23	-0.04						p(15) =	0.2
						Total acceptable:				0		

Player I - GRIC
Player II - Federal Government
Player III - Upper SP Basin Agriculture
Player IV - Lower SP Basin Agriculture
Player V - Mines

payoff/acceptability matrix indicated the scenarios acceptable to the government involved minimal if any federal expenditure. When the scenarios acceptable to the government under the weighting scheme highly emphasizing minimizing government expenditures were examined, only those scenarios with no government involvement were acceptable, as expected. Under the weighting scheme where all weights for all players were individually equal, only scenario 5 was considered acceptable. The apparent willingness by the San Pedro users to supply the increased 41,000 acre-feet is puzzling.

6.4 An Analysis of Uncertainty in Subjective Adjudication Probabilities

Recall that probabilities were assigned to the adjudication scenarios to account for the uncertainty of a final adjudicated judgement. These probability assignments were critical to determination of scenario acceptability in that they were used to calculate a single expected adjudication payoff which became the threshold value against which negotiation payoffs were compared and acceptability defined. All analyses so far held the adjudication probabilities for scenarios 13, 14, and 15 constant at 0.7, 0.1, and 0.2 respectively, reflecting the likelihood that, should the conflict be resolved through adjudication, the GRIC would receive entitlement to the water, and all players would have to pay court costs (scenario 13). The likelihood that the GRIC would not win entitlement to the water in an adjudicated resolution (scenario 14) was deemed very low, hence a probability assignment of 0.1. The probability that the GRIC would receive water and that intrabasin water trading could occur (scenario 15), was also deemed low and was assigned a probability of 0.2. But what if assignments for scenarios 13, 14, and 15 were 0.2, 0.7, and 0.1, respectively?

To assess the effect these subjective probability assignments had upon the jointly acceptable negotiation set, various sets of probability assignments were entered into the payoff/acceptability matrix, and the number of scenarios comprising the jointly acceptable negotiation set was noted, as well as which scenarios comprised the set. This resulted in a frequency diagram (Figure 6.1) which showed the number of acceptable scenarios at various probability assignments. Table 6.6 lists the negotiation scenarios which were jointly acceptable. Several items are noted upon examination of Figure 6.1 and Table 6.6.

First, with only one exception, regardless of the probability assignments, there exist scenarios where a negotiated settlement yields higher payoffs to each player than adjudication. Second, while some sensitivity to probability assignments was evident, the set of negotiation scenarios 10, 11, and 12 appeared to be relatively stable, indicating the preference among all players to substitute money for water, under the specified conditions. Third, of the three stable negotiation scenarios, scenario 11 (the San Pedro water users are responsible for supplying the entire cash award) is least desirable because it falls out of the acceptable set more often than the other scenarios (Table 6.6). Scenarios 10 and 12 involve the federal government supplying all (10) or 50% (12) of the cash award. The federal contribution is critical to negotiation. Fourth, as the probability of adjudication scenario 13 (GRIC wins water) **decreased**, more scenarios were acceptable, indicating an increased willingness on the part of the GRIC to negotiate. Adjudication scenario 15 (GRIC wins water but marketing occurs between the Upper and Lower San Pedro Basin players) showed the opposite effect--as the probability **increased**, more scenarios were acceptable. Since the only difference between scenarios 13 and 15 was the occurrence of intrabasin marketing, this result indicated an increased willingness on the part of the San Pedro players to negotiate if trading among themselves allowed more options for settlement.

Figure 6.1 Frequency diagram of acceptable negotiation strategies at selected probabilities.

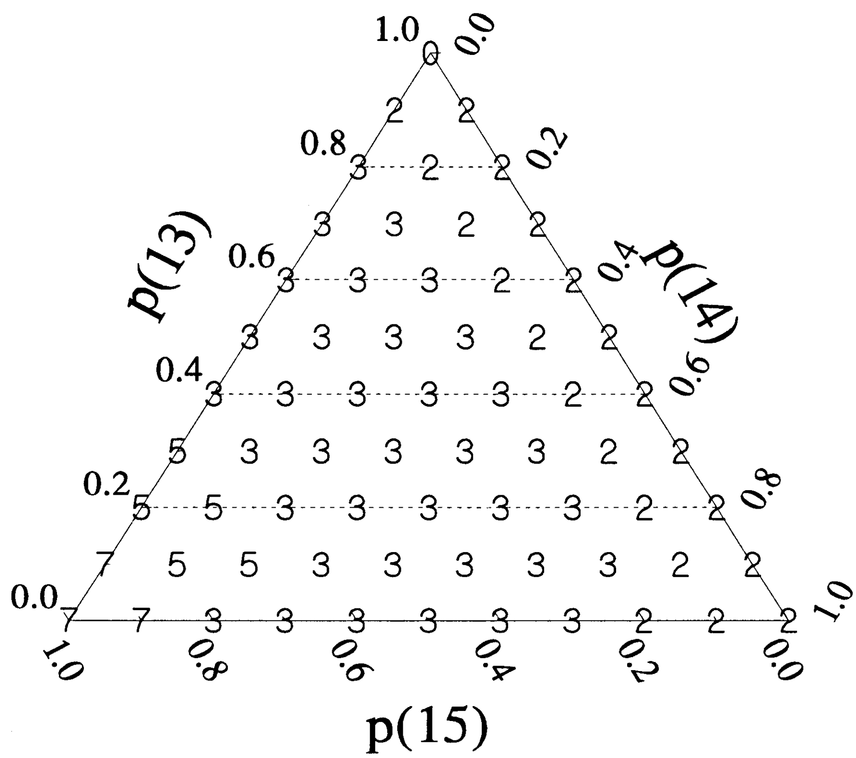

Table 6.6 Probability/sensitivity table for 51,000 acre-foot liability, original weights.

p(13)	p(14)	p(15)	# Strat	Acceptable Scenarios						
0	0	1	7	2	4	7	9	10	11	12
0	0.1	0.9	7	2	4	7	9	10	11	12
0	0.2	0.8	3	10	11	12				
0	0.3	0.7	3	10	11	12				
0	0.4	0.6	3	10	11	12				
0	0.5	0.5	3	10	11	12				
0	0.6	0.4	3	10	11	12				
0	0.7	0.3	3	10	11	12				
0	0.8	0.2	2	10	12					
0	0.9	0.1	2	10	12					
0	1	0	2	10	12					
0.1	0	0.9	7	2	4	7	9	10	11	12
0.1	0.1	0.8	5	7	9	10	11	12		
0.1	0.2	0.7	5	7	9	10	11	12		
0.1	0.3	0.6	3	10	11	12				
0.1	0.4	0.5	3	10	11	12				
0.1	0.5	0.4	3	10	11	12				
0.1	0.6	0.3	3	10	11	12				
0.1	0.7	0.2	3	10	11	12				
0.1	0.8	0.1	2	10	12					
0.1	0.9	0	2	10	12					
0.2	0	0.8	5	7	9	10	11	12		
0.2	0.1	0.7	5	7	9	10	11	12		
0.2	0.2	0.6	3	10	11	12				
0.2	0.3	0.5	3	10	11	12				
0.2	0.4	0.4	3	10	11	12				
0.2	0.5	0.3	3	10	11	12				
0.2	0.6	0.2	3	10	11	12				
0.2	0.7	0.1	2	10	12					
0.2	0.8	0	2	10	12					
0.3	0	0.7	5	7	9	10	11	12		
0.3	0.1	0.6	3	10	11	12				
0.3	0.2	0.5	3	10	11	12				
0.3	0.3	0.4	3	10	11	12				
0.3	0.4	0.3	3	10	11	12				
0.3	0.5	0.2	3	10	11	12				
0.3	0.6	0.1	2	10	12					
0.3	0.7	0	2	10	12					
0.4	0	0.6	3	10	11	12				
0.4	0.1	0.5	3	10	11	12				
0.4	0.2	0.4	3	10	11	12				
0.4	0.3	0.3	3	10	11	12				
0.4	0.4	0.2	3	10	11	12				
0.4	0.5	0.1	2	10	12					
0.4	0.6	0	2	10	12					
0.5	0	0.5	3	10	11	12				
0.5	0.1	0.4	3	10	11	12				
0.5	0.2	0.3	3	10	11	12				
0.5	0.3	0.2	3	10	11	12				
0.5	0.4	0.1	2	10	12					
0.5	0.5	0	2	10	12					
0.6	0	0.4	3	10	11	12				
0.6	0.1	0.3	3	10	11	12				
0.6	0.2	0.2	3	10	11	12				
0.6	0.3	0.1	2	10	12					
0.6	0.4	0	2	10	12					
0.7	0	0.3	3	10	11	12				
0.7	0.1	0.2	3	10	11	12				
0.7	0.2	0.1	2	10	12					
0.7	0.3	0	2	10	12					
0.8	0	0.2	3	10	11	12				
0.8	0.1	0.1	2	10	12					
0.8	0.2	0	2	10	12					
0.9	0	0.1	2	10	12					
0.9	0.1	0	2	10	12					
1	0	0	0							

Nine separate cases of the sensitivity of outcomes to probability assignments were examined where weights and water liabilities were varied. Generally, the number and composition of the jointly acceptable negotiation set was sensitive to probability assignments. Among all nine cases examined, the higher number of jointly acceptable scenarios was concentrated in the region where probability assignment for scenario 13 was low and for 15 was high, again indicating some sensitivity to player willingness and the effect of intrabasin trading. Adjusting the payoff function seemed to increase the number of acceptable scenarios, again perhaps due to increased payoffs associated with potentially large losses. The number of acceptable scenarios also seemed to increase slightly when players were indifferent among their objective measures. Finally, the number of acceptable scenarios decreased markedly when the San Pedro water liability was increased to 99,000 acre-feet per year.

CHAPTER 7

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

7.1 Summary and Conclusions

Conflicts over Indian water rights involve a significant portion of the limited water resources in the West. As the human population continues to grow, these conflicts will become more intense. The objective of this study was to develop a framework to aid in the settlement of those conflicts. Specifically, it was believed that negotiated settlements, where participants agreed on the terms of the settlement, existed such that all participants would "win". This study presented a framework whereby information pertinent to the conflict could be organized, altered (if necessary), and potential negotiated ("win-win") settlements discovered.

This study began with a description of water rights. Essentially, two conflicting doctrines regarding these water rights have emerged in the West. While most Western states adopted the prior appropriation doctrine, Indian water rights are potential water rights, based upon land use, are unquantified, and are established as of the date of reservation. Conflict ensues because much of the water already in use throughout the West, in fact, developed by the federal government for the primarily non-Indian settlement of the West, is the same water now being claimed by Indians whose reservation establishment often dates back to late 19th or early 20th century, prior to most non-Indian claims to water. However, court action defining Indian water rights, especially in relation to other water rights, is inconsistent. In general, while the courts have upheld the right of Indians to water, the decisions and acts of state and federal legislatures and courts have not favored the out-and-out perfection of those rights.

The General Adjudication of the Gila River System and Sources involving most of the State of Arizona, has evolved into an extremely large, complex and slow-moving court action. After 22 years, the proceedings appear mired in, among others, issues of groundwater/surface water interaction and jurisdiction.

The largest single claim to water, totaling 1.5 million acre-feet per year, has been made by the Gila River Indian Community (GRIC). Upstream of the GRIC is the San Pedro River Basin, a tributary of the Gila River, where the entire undepleted annual flow is, potentially, a small but critical component of the GRIC claim. Information regarding the Gila Adjudication, the GRIC, and the San Pedro River Basin provided a specific conflict situation to demonstrate the search for a possible negotiated resolution.

A conceptualization of the conflict was developed using various tools. The conflict was conceptualized as a decision problem--should participants negotiate or not? Elements of game theory were used to describe the conflict. The use of game theory highlighted the concept that outcomes were jointly determined by all participants (players). Central to game theory is the concept of outcome payoffs. Payoff was a concept central to both game theory and the objectives of this study. While payoffs might be valued differently by the players, game theory incorporated the theory of utility--a single value expressing player preference--so that a payoff would be measured in terms of player utility. A player would choose to achieve the highest utility. In application, it was perceived that a negotiated settlement would be one in which all players realized a higher payoff (as measured by utility) by reaching a negotiated resolution than by continuing with a non-negotiated (adjudicated) resolution.

Five players were identified. Once identified, possible outcomes were generated. Outcome scenarios began as individual player actions, i.e., demanding or supplying money or water. These player actions were merged with components common to other negotiated settlements. Twelve negotiated settlement scenarios were generated, as well as three adjudicated settlements. Because players were assumed to have general objectives which they were trying to achieve, each scenario was decomposed into measurable objective attributes. A consistent weighting among attributes was generated through role-playing using an interactive computer program, MATS (Multiattribute Tradeoff System). MATS also generated player utilities for each scenario.

Three adjudication scenarios were generated to encompass the range of adjudicated outcomes. Subjective probabilities were assigned to each scenario. A single probability weighted adjudicated scenario payoff was generated to account for the uncertainty in an adjudicated outcome. Each negotiated scenario payoff was compared to the adjudicated payoff for each player. A player would choose a negotiated scenario if he received a higher payoff than from adjudicating. This decision defined a set of individually acceptable scenarios. Scenarios which were common to all players constituted the jointly acceptable negotiated scenario set. Thus, for any scenario in the jointly acceptable set, the payoff to each player to negotiate was higher than adjudicating.

Under specified conditions, it was discovered that the jointly acceptable negotiation set was not empty. Three scenarios comprised the jointly acceptable negotiation set. The element common to these scenarios was the award of money instead of water to the GRIC. The set of scenarios appeared stable despite the probabilities used to weight the uncertain adjudication scenarios. The outcome suggested that the monetary award was worth more to the GRIC than "wet" water. It also suggested that the water was worth more in the San Pedro Basin to the San Pedro users, than to the GRIC.

At the onset of the study, it was stated that none of the values were considered particularly sacred. The object of the study was methodological development. However, the substantive results of the study--the existence of a negotiation set involving monetary payment instead of water payment--begged the question of how sensitive the outcome was to the amount of water. Uncertainty of the data used and the incorporation of new data allowed for the examination of solution set sensitivity and the ability of the developed framework to allow for changing conditions. Uncertainty in individual player weights was examined by assuming players were indifferent among their objectives; all weights were set equal. Again, the jointly acceptable set was relatively insensitive to these changes. However, when the amount of undepleted flow for the San Pedro River and the maximum GRIC claim was changed from 51,000 acre-feet per year to 99,000 acre-feet per year, no negotiated scenarios were jointly acceptable. Further analysis suggested this null set was quite stable.

The results suggest:

1. settlement scenarios exist.
2. through negotiated settlement, all players can be made "better off" than by adjudicating.
3. negotiated settlement can allow for trade beneficial to disputants outside adjudicatory proceedings.
4. some values are more critical than others to negotiated dispute resolution. For example, the determination of undepleted flow at the confluence of the San Pedro River is more critical than proper identification of player preferences under the circumstances tested. Thus, more resources should be expended upon generation of an undepleted flow value than upon the identification of more subjective player preference weights.

7.2 Recommendations for Future Study

The existence of a framework to organize and assess information pertinent to Indian water right conflict resolutions allows several avenues for further study. Some recommendations follow:

1. A continuation of the analysis presented in Chapter 6 is suggested. Altering player weights, altering inputs, even modifying or adding player objectives in a regular manner can lead to the development of a defined response function, which could be used to generate more feasible outcomes. The use of the framework becomes iterative--a tool to define and then refine settlement options.

2. The economic inputs for the valuation process were not adjusted from the work of Bazlen (1989). Uncertainty in these values can be assessed as suggested above.

3. Over a four-year period beginning in 1985, water use by the Magma Copper Company within the lower San Pedro Basin rose from 3140 to 19,330 acre-feet per year (ADWR, 1987, 1990), more than double the agricultural water use. Since then, the company has been purchased by Broken Hill Proprietary, an Australian mining enterprise. The mining operation is now a significant player. The valuation procedure should be adjusted to reflect new water use values.

4. The municipal water use within the Sierra Vista/Fort Huachuca area should be more explicitly accounted for. While it was suggested that groundwater/surface water interaction was an issue central to the particular water rights conflict, it was ignored for this study to allow for framework development, and because groundwater is not appropriable under current Arizona water law. It is suggested that the municipalities be considered a player, and that scenarios be generated in which groundwater is considered appropriable. Structurally, this should be relatively simple. However, it would require more sophisticated hydrologic analyses. As suggested earlier, time scale may be the crux of the connectivity issue, thus the analysis must be more dynamic. Currently, the conflict is addressed from one point in time. A more dynamic application would allow the exploration of the possible effects of continued pumping of the regional aquifer on a negotiated resolution within the San Pedro Basin.

5. An objective of this study was to assist in the resolution of Indian water rights conflicts with "fair and equitable" solutions. No attempt was made at defining these terms, but it was recognized that they are critical to conflicts in general and Indian water rights specifically, especially as some past negotiated settlements may be characterized as "unfair and inequitable". In the study, fairness and equity were accounted for assuming all players were of equal standing and ability, had access to the same information, and by acknowledging the separate but equal goals of the players. Game theory provides some techniques for the analysis of bargaining position through which issues such as fairness and equity can be explored The framework can be used to assess consequences of this analysis on the possibility of resolution.

6. A recent topic within the field of decision analysis is the Decision Support System (DSS), which can be described as an information system used to support decision making activities (Dyer et al., 1992). As research regarding decisions continues, the complexity of decision making seems to increase as does the amount of information needed. Computer-aided decision making tools are being used in several environmental applications, including water quality management (Yakowitz et al., 1993). The framework presented within this study can be viewed as a prototype DSS so that further methodological design and improvement of the framework can be assisted by developments within the field of DSS.

APPENDIX A

SAMPLE OF VALUATION SPREADSHEET

Sample Valuation Spreadsheet for Indian Water Right Conflicts
by B. Bazlen (modified by R. Shillito)

CONFLICT

This spreadsheet is designed for the water right conflict involving the Gila River Indian Community (GRIC) and the San Pedro water users. Fifteen scenarios, previously defined, are valuated. These scenarios include 12 negotiation scenarios and 3 adjudication scenarios. Five players are defined including: the GRIC, the federal government, Upper San Pedro Basin Agricultural (USPBAg) water users, Lower San Pedro Basin Agricultural (LSPBAg) water users, and Mines within the Lower San Pedro Basin. Objectives and measurable attributes for each player have been defined prior to this procedure.

CONTENTS

The valuation spreadsheet is in three parts:

I. Assumptions
II. Calculations
III. Impact Assignment Tables.
   Two tables are constructed to reflect the dollar and water impacts of the 15 negotiation/adjudication scenarios identified.
   Table 1 - Total dollars and AF exchanged.
   Table 2 - Impacts to objectives of the players (explanations of objective measures are in the tables).

REFERENCES

Citations to specific references can be found in Bazlen (1989).

I. ASSUMPTIONS

A. San Pedro Basin

If GRIC water claims are recognized, the San Pedro basin is likely to be liable to supply an average additional 10,000 af/yr at the confluence with the Gila River at Winkelman (the total 51,000 af/yr undepleted flow estimate is from MODSIM).

Only appropriable water is liable to supply the flow.

Appropriable water use in the San Pedro basin is limited to pumping from the floodplain alluvium and from wells from which 90 days of continuous pumping would deplete the floodplain aquifer by 50% of the amount pumped (Goodfarb, 1988). According to this rule, only agricultural uses throughout the basin and lower basin mining (ASARCO) are using appropriable water.

1956 is used as the cut-off date for junior and senior rights, simply because that is the year for which decent data are readily available (ADWR, 1987).

ASARCO may have some senior rights, however here all lower basin mining is assumed to have post-1956 rights. (The amount of water is small and identifying the small quantity of senior rights is deemed unnecessary.)

San Pedro liability assignment

Percentages of junior rights (liability) are split between sub-basins according to land brought into production since 1956. ASARCO water is added to this. ASARCO figures are average use for the period 1961 - 1987.

Water Rights Since 1956

Water User	Acreage	Average AF/AC	Water Use AF	Percent of use (liability)
SV Ag /1	2895	3.43	9930	0.30
Ben Ag	3212	3.43	11017	0.33
Red Ag	2149	3.43	7371	0.22
Wnk ag /2	828	4.00	3312	0.10
LB Min			1800	0.05
Total	9084		33430	1.00

/1 reflects retirement of Tenneco (BLM) land
/2 includes Aravaipa

Aggregated Hydrological liability

Water User	Acreage	Average AF/AC	Water Use AF	Percent of use (liability)
UB Ag	6107	3.43	20947	0.63
LB Ag	2977	3.43	10683	0.32
LB Min	0	0.00	1800	0.05
	9084		33430	1.00

Delivery liabilities are translated into true effective liabilty under all scenarios using average channel loss coefficients for each player and scenario.
All coefficients derived from MODSIM.

B. GRIC

Of an increase of 10,000 AF at the confluence only 9,000 AF will reach the eastern edge of the reservation (based on precip. and gage flow data for the Gila River).
Losses between the edge of the reservation and actual farms are not accounted for (too difficult to be accurate).

The CAP delivery alternative also uses 9,000 AF to evaluate benefits to the GRIC, since this is all the San Pedro water they could receive.

To make use of new water the GRIC will have to develop new land. Development costs are based upon Franzoy Corey (1985) Alternative 2 for the Gila River Farms area.
Alternative 2 utilizes the Pima delivery point which Franzoy Corey (1985) identify as the one to be used for San Pedro water. The undeveloped Gila River Farms area is the closest and largest tribally owned area.

The discount rate is 10% for annualizing capital investment or capitalizing annual returns in all cases.

Crop mix is 67% cotton and 33% alfalfa (Franzoy and Corey identified cotton, alfalfa, and wheat as desired crops with aggregate percentage of 68% in base condition crop mix. The MVP of water to wheat is negative for undeveloped land so here the Franzoy Corey percentages of cotton and alfalfa are normalized to 100% of new irrigated land.

Cash award figures are annualized for direct comparison with other alternatives.
Cash award = LR MVP * AF + wages that would have been generated by 9000 AF.

II. CALCULATIONS

A. San Pedro Basin

1. Loss Coefficients sub-basin to Confluence (from MODSIM)

SV	0.65
Ben	0.54
Red	0.40
Wnk	0.14
AVG UB	0.60
AVG LB	0.27

These values are 1987 estimates and are manually inserted here.

Upper Basin Totals

	Ac planted Ac	Water Applied AF/yr	Operating profit $/yr	Total Profit $/yr	MVP wat* wat app $/yr	Wgtd MVP
Ag Jnr	5190	17815	1123047	607206	810835	
Ag Snr	4169	14310	902102	487739	651304	
Total	9359	32125	2025149	1094945	1462139	45.51

Lower Basin Totals

	Ac planted Ac	Water Applied AF/yr	Operating profit $/yr	Total Profit $/yr	MVP wat* wat app $/yr	Wgtd MVP
Ag Jnr	2675	9702	597294	294958	405854	
Ag Snr	3331	12562	760686	350595	494183	
Total	6006	22264	1357980	645553	900037	40.43

Weighted Averages

	Operating Profit $/ac	Total Profit $/ac	MVP $/AF	AF/AC
UB AG	216.39	116.99	45.51	3.43
LB AG	226.10	107.48	40.43	3.71
LB MINE			302.00	

Following table allows for no intrabasin trade

10000 AF total liability - hydro rule

	% liabil	Delivrd AF liab AF	effect lost AF (w/trans) AF	operating profit $/ac	total profit $/ac	Wtd MVP water $/AF	LR lost MVP * delivrd $	LR lost MVP * effec AF $	Acres Out of Prod AC
UB AG	0.63	6266	15665	216.39	116.99	45.51	285187	712968	4564
LB AG	0.32	3196	4378	226.10	107.48	40.43	129186	176967	1181
LB MINE	0.05	538	738			302.00	162608	222751	
Total	1.00	10000	20780				576981	1112686	5745

Possible trade allowed for following table

San Pedro Water solutions

Total 10876 AF Ag water available in Winkleman sub-basin
Total 2688 Acres in Winkelman sub-basin
Total 22265 AF Ag water in lower basin
Total 6006 acres in lower basin
Avg. AF/AC in Winkelman sub-bas 4.05

10000 AF total liability - hydro rule

	Percent Liabil	need to deliver AF	w/ loss from Wnk AF	LB per AF Price $/AF	Total Price $	AF bought from LB AG	LB Acres out of Prod Ac
UB AG	0.63	6266	7286	40.43	294539	7286	1799
LB AG	0.32	3196	3716	40.43	150216	3716	917
LB Mine	0.05	538	626	40.43	25310	626	155
Total	1.00	10000	11628		470066	11628	2871

B. CAP costs

Upon completion, $58/AF variable costs for all users (Colby) plus Bureau of Reclamation (BoR) assessment for repayment.

BoR assessment

M&I	In 1990 $5/AF growing to $40/AF in 2025 (i = 3.342%)
Non-Indian Ag	$2/AF w/ no increase, no interest
Indian	deferred payment as long as water used on tribal land

Total CAP costs

	$/AF 1990	$/AF 2025
M&I	63	98
Non-Indian Ag	60	60
Indian (on res)	58	58

9000 AF CAP water - hydro rule

	% liabil	Delivered AF liab AF	$58/AF per yr $	$60/AF per yr $	$63/AF per yr $
UB AG	0.63	5639	327081	338360	355277
LB AG	0.32	2876	166813	172565	181193
LB MINE	0.05	485	28106	29076	30529
total	1	9000	522000	540000	567000

To change CAP cost assumption in impact tables, put assumed total cost
here => 522000 This cell is named CAPCOST

C. Value of additional water to GRIC from surface water

10% discount rate to undeveloped land

Undepleted flow - present outflow:	10,000	AF/YR	Additional water
90% of 10,000 AF/YR:	9000	AF/YR	Change D220 (WATQUAN) to change water assumption (all other changes will be automatic).
Surface water delivery (wt. avt. us	5.41	AF/AC	

1664 Acres plantable with San Pedro water for: *0.67 cotton*
0.33 alfalfa

	addition acres acres	applied AF/ac	AF	1987 Operating Profit $/ac	Total Profit $/ac	Operating Profit $/yr	Total Profit $/yr	SR MVP $/af	LR MVP $/af	SR MVP * AF $/yr	LR MVP * AF $/yr
U Cot fur	1115	5	5573	403.96	49.78	450255	55485	80.79	16.00	450244	89168
Alfalfa	549	6.25	3431	330.61	17.98	181499	9871	52.90	7.71	181508	26454
Total	1664		9004		68	631754	65356			631751	115622
wtd avg		5.41		380	39			70.16	12.84		

Employment - assumes 15 FT and 9 PT employees per 2300 acres (no. of employees and wages from F-C Shuk Toak plan).

	# employed people	Avg wage $/yr	total wages $/yr
full time	11	12064	130888
seasonal	7	1969	12818
Total	17		143706
wgt avg		8127	

Development costs for 1664 acres 9000 AF

Alt 2 - Pima Delivery, GRF undev. area

	1985 $ $/ac	1985 $ M $	1987 $ $/ac	1987 $ M $
land development	1490	2478743	1573	2617553
water dist devel	286	475786	302	502430
lnd & wat Developmen	1776	2954529	1875	3119982

a/ using GNP price deflater

1664 acres

Other costs (GRF undev. area proportion), 1987

	$ M
25% for Contingencies (F-C, p. 549)	779996
20% for Admin,reports, studies, design etc.	623996
	1403992

Total development for:	1664	acres	9000 AF	4523974	Capitalized
				452397	Annualized

GRIC Total Benefits & Costs 1664 acres

	Annual Benefits	Annual Costs

Oper Prft	631754	
Tot Prft	65356	
MVP * Wat	115622	
Wages	143706	
Development		452397
	Non Add	

III. IMPACT ASSIGNMENT TABLES

Explanation and Cell Names for Tables

Total Cash Award = LR MVP * Q + Wages =	259328	This cell named ICASHAWARDANN
EcD = LR MVP * AF + wages:		Cell names are AVGIMVPLR, ITOTAC, IWAGE9000
TrS = SR MVP * AF:		Cell names ar AVGINMVPSR, ITOTAC
CulP = Acres used and type of use (jobs too?)		
Develop Grant = AG Dev or Cash Award:		Cell names are INTOTDEVCSTANN, ICASHAWARDANN
Industrial Jobs = .0001 * Cash Award:	26	This cell named IINJOBS, where a Avg Ind wage = 12K /yr
Industrial wages =	311194	This cell named IINWAGE; need to need to manually adjust if switch wage

Industrial acres are assumed to be small (aprox 3 acres per $M 0.25).

TABLE 1 - SCENARIO MATRIX

INDIAN WATER RIGHTS PROJECT - Settlement Options
Note: all dollar figures are annual

SCENARI NO.		GRIC	FEDS	UPPER SP FARM	LOWER S FARM	LOWER S MINING	CAP	Total
1.	AF	9000	0	0	-11628	0		-2628
	$	452397	-922463	0	470066	0		-0
2.	AF	9000	0	0	-11628	0		-2628
	$	452397	-452397	-294539	319849	-25310		0
3.	AF	9000	0	-15665	-4378	-738		-11780
	$	452397	-452397	0	0	0		0
4.	AF	9000	0	0	-11628	0		-2628
	$	0	0	-294539	319849	-25310		0
5.	AF	9000	0	-15665	-4378	-738		-11780
	$	0	0	0	0	0		0
6.	AF	9000	0	0	0	0	-9000	0
	$	452397	-974397	0	0	0	522000	0
7.	AF	9000	0	0	0	0	-9000	0
	$	452397	-452397	-327081	-166813	-28106	522000	-0
8.	AF	9000	0	0	0	0	-9000	0
	$	0	-522000	0	0	0	522000	0
9.	AF	9000	0	0	0	0	-9000	0
	$	0	0	-327081	-166813	-28106	522000	-0
10.	AF	0	0	0	0	0	0	0
	$	259328	-259328	0	0	0	0	0
11.	AF	0	0	0	0	0	0	0
	$	259328	0	-162493	-82872	-13963	0	-0
12.	AF	0	0	0	0	0	0	0
	$	259328	-129664	-81246	-41436	-6982	0	-0
13.	AF	9000	0	-15665	-4378	-738	0	-11780
	$	-50000	-100000	-2500	-2500	-10000	0	-165000
14.	AF	0	0	0	0	0	0	0
	$	-50000	-100000	-2500	-2500	-10000	0	-165000
15.	AF	9000	0	0	-11628	0	0	0
	$	-50000	-100000	-297039	-152716	-35310	0	-635066

GRIC Cash Awards	Cell Names
LR MVP * AF + Wages	ICASHAWARDANN
Annualized Values used for awards	
MVP based on undeveloped land (10% discount rate)	AVGIMVPLR
Wages based on acres plantable with 9000 AF	IWAGE9000
or 12K /yr for Industry	IINWAGE

TABLE 2 - OBJECTIVES/IMPACTS MATRIX

INDIAN WATER RIGHTS PROJECT - Settlement Options
Note: all dollar figures are annual

SCENARIO		GRIC						FEDERAL INDIAN POLICY					FEDS	USPBAg			LSPBAg			TOTAL AG			MINING
NO.	Objective	Ecd	TrS	CulP	Lnd use	jobs	Develop Grant	Ecd	TrS	CulP	Lnd use	jobs	MinC	Acres lost RuL	%	$ MxI	Acres lost RuL	%	$ MxI	Acres lost RuL	%	$ MxI	Min Cost
1.	VARIES	9000		1664	Ag	17		9000		1664	Ag	17	0	0	0		-3137	-52		-3137	-20		0
	$	259275	631460				452397	259275	631460				-922463			1462139			900037			2362176	0
2.	VARIES	9000		1664	Ag	17		9000		1664	Ag	17	0	0	0		-3137	-52		-3137	-20		0
	$	259275	631460				452397	259275	631460				-452397			1167600			749821			1917420	-25310
3.	VARIES	9000		1664	Ag	17		9000		1664	Ag	17	0	-4564	-49		-1181	-20		-5745	-37		-738
	$	259275	631460				452397	259275	631460				-452397			749171			723070			1472241	0
4.	SEE EXPL	9000		1664	Ag	17		9000		1664	Ag	17	0	0	0		-3137	-52		-3137	-20		0
	$	-193123	631460				0	-193123	631460				0			1167600			749821			1917420	-25310
5.	SEE EXPL	9000		1664	Ag	17		9000		1664	Ag	17	0	-4564	-49		-1181	-20		-5745	-37		-738
	$	-193123	631460				0	-193123	631460				0			749171			723070			1472241	0
6.	SEE EXPL	9000		1664	Ag	17		9000		1664	Ag	17	0	0	0		0	0		0	0		0
	$	259275	631460				452397	259275	631460				-974397			1462139			900037			2362176	0
7.	SEE EXPL	9000		1664	Ag	17		9000		1664	Ag	17	0	0	0		0	0		0	0		0
	$	259275	631460				452397	259275	631460				-452397			1135058			733224			1868282	-28106
8.	SEE EXPL	9000		1664	Ag	17		9000		1664	Ag	17	0	0	0		0	0		0	0		0
	$	-193123	631460				0	-193123	631460				-522000			1462139			900037			2362176	0
9.	SEE EXPL	9000		1664	Ag	17		9000		1664	Ag	17	0	0	0		0	0		0	0		0
	$	-193123	631460				0	-193123	631460				0			1135058			733224			1868282	-28106
10.	SEE EXPL	0		3	IND	26		0		3	IND	26	0	0	0		0	0		0	0		0
	$	700185	388992				259328	700185	388992				-259328			1462139			900037			2362176	0
11.	SEE EXPL	0		3	IND	26		0		3	IND	26	0	0	0		0	0		0	0		0
	$	700185	388992				259328	700185	388992				0			1299646			817165			2116811	-13963
12.	SEE EXPL	0		3	IND	26		0		3	IND	26	0	0	0		0	0		0	0		0
	$	700185	388992				259328	700185	388992				-129664			1380893			858601			2239494	-6982
13.	SEE EXPL	9000		1664	Ag	17		9000	0	1664	Ag	17	0	-4564	-49		-1181	-20		-5745	-37		-738
	$	-193123	581460				0	-193123	581460				-100000			746671			720570			1467241	-10000
14.	SEE EXPL	0		0		0		0		0		0	0	0	0		0	0		0	0		0
	$	0	-50000				0	0	-50000				-100000			1459639			897537			2357176	-10000
15.	SEE EXPL	9000		0	IND	17		9000		0	IND	0	0	0	0		-3137	-52		-3137	-20		0
	$	-193123	581460			0	0	-193123	581460			0	-100000			1165100			277255			1442354	-35310

Abbreviations		Measured by
EcD -	Economic Development	LR MVP * AF + Wages for AG; 15% return on Investment Capital (award) for Industry + Ind wages (avg 12K / yr)
TrS -	Tribal Soveriegnty	SR MVP * AF for AG; 3% tax revenue on investment (Capital = cash award) for Industry
CulP -	Cultural Pluralism	Number of acres/use type (A = Agriculture Ind = Industry); also jobs for Industry
MaxI -	Maximize Income	Maximize: Revenue - Cost
MinC -	Minimize Cost	Minimize Cost
RuL -	Rural Lifestyle	Acres lost to farming and percent lost of total present acres

Indian Cash Awards (IC) based on AG: LR MVP * AF + wages that they would have had

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