11-1-2007

Using instream flows on the Gila River to provide benefits for the environment and the economy

Emily Geery

Professional Project Report
Community and Regional Planning & Water Resources Programs
University of New Mexico

Using Instream Flows on the Gila River to Provide Benefits for the Environment and the Economy

By
Emily Geery
Committee
Dr. William Fleming, Chair
Dr. Stephen Wheeler
Sarita Nair, JD

A Professional Project Report Submitted in Partial Fulfillment of the Requirements for the Degrees of
Master of Community and Regional Planning, Natural Resources Concentration
Master of Water Resources, Policy Management Concentration
Community and Regional Planning Program
Water Resources Program
Albuquerque, NM
December 2006

Committee Approval

The Master of Water Resources Professional Project Report of **Emily Geery** entitled **Using Instream Flows on the Gila River to Provide Benefits for the Environment and Economy** is approved by the committee:

Chair ______________________ Date October 12 '06

______________________ 10/12/06

______________________ 10/12/2006

______________________ ______________________

______________________ ______________________

______________________ ______________________

ACKNOWLEDGMENTS

I would like to acknowledge my committee for their continued support throughout this project. I would like to thank Bill Fleming, the chair of my committee, for his encouragement to think like a watershed. His holistic perspective guided me to think about the big picture. Bill was always available to answer questions, share ideas and talk. He was extremely helpful in developing my methodology. He is a wonderful mentor and has taught me more than I can thank him for.

I would also like to thank Sarita Nair for dedication to this project and being a wealth of knowledge. Sarita is a gifted teacher and really helped me to formulate and develop my ideas for this project. Her constant attention to detail and prompt responses to any questions I had were greatly appreciated. Without her, I wouldn't have been able to achieve my goals for this professional project.

Steve Wheeler has also been a tremendous asset to this project as he guided me in writing. His knowledge of sustainable planning was extremely helpful as he helped me to continue to think and write about strategies for water resource and community planning. He continually brought new ideas to the project. His interest in mobilizing communities provided me with hope and motivation to continue to work towards creating positive change.

Table of Contents

Table of Contents

List of Figures

List of Tables

Appendices

ABSTRACT

Professionals within the fields of water resources and community and regional planning have engaged in dialogue about how to balance water consumption with development patterns in the western United States. Central to this discussion is a debate about future water management of the Gila River. There is a wide spectrum of opinions regarding the value of leaving water in the river for environmental reasons versus diverting it from the river for increased commercial development.

The 2004 Arizona Water Settlements Act (AWSA) provides the state of New Mexico with 140,000 acre-feet in any ten-year period of water rights on the Gila River in perpetuity. The AWSA also grants $66 million to $128 million dollars (depending on the type of water project being pursued) for New Mexico to use to meet water demand in southwestern New Mexico. Decisions regarding how to allocate the funding and use the water, in compliance with Consumptive Use Forbearance Agreement (CUFA), need to be made by 2014. The New Mexico Interstate Stream Commission (NMISC) will make these decisions in consultation with the Southwest New Mexico Water Planning Board, the citizens of southwest New Mexico and other interested parties.

In this paper, I examine three options for using the newly confirmed water rights as instream flows on the Gila River and discuss how these options are environmentally and economically viable. I recommend using a combination of methods to support instream flows that includes the purchasing and leasing of instream flows in the private market, leasing the water rights to Arizona and dedicating the water rights to instream flows.

ACRONYMS

AF:	Acre-feet
AFY:	Acre-feet per year
AWSA:	Arizona Water Settlements Act
BBER:	Bureau of Business and Economic Research
BOR:	Bureau of Reclamation
CAP:	Central Arizona Project
CFS:	Cubic Feet per Second
CUFA:	Consumptive Use Forbearance Act
CVM:	Contingent Value Method
EIS:	Environmental Impact Statement
GCC:	Gila Conservation Coalition
IFIM:	Instream Flow Incremental Methodology
NEPA:	National Environmental Policy Act
NMFS:	National Marine Fisheries Service
NMISC:	New Mexico Interstate Stream Commission
OSE:	Office of the State Engineer
TCM:	Travel Cost Method
TNC:	The Nature Conservancy
USFWS:	United States Fish and Wildlife Service
USGS:	United State Geological Survey
WTP:	Willingness to Pay

CHAPTER 1: INTRODUCTION

A. Research Question

Professionals within the fields of water resources and community and regional planning have engaged in dialogue about how to balance water consumption with development patterns in the western United States. Central to this discussion is a debate about future water management of the Gila River. There is a wide spectrum of opinions regarding the value of leaving water in the river for environmental reasons versus diverting it from the river for increased commercial development. As a researcher, watershed planner, and river runner, I locate myself on the side of the spectrum committed to keeping the Gila River wild.

In this professional project, I pose the research question: *What options for using the newly acquired water rights from the Arizona Water Settlements Act as instream flows on the Gila River provide environmental and economic benefits that are compelling enough to ensure that the ecological integrity of Gila River is not compromised by growth and development?*

B. Arizona Water Settlements Act

The 2004 Arizona Water Settlements Act (AWSA) provides the state of New Mexico with 140,000 acre-feet in any ten-year period of new water rights on the Gila River in perpetuity. The AWSA enables New Mexico to exchange 18,000 afy of Colorado River water for an equal amount of Gila River water. The AWSA also grants New Mexico $66 million to $128 million dollars in non-reimbursable federal funding to develop water resources (NMISC 2006). While 18,000 afy are available to New Mexico, the New Mexico Interstate Stream Commission (NMISC) (also referred to as the

Commission) recognizes that 4,000 afy must stay in the Gila River system to meet the downstream obligations to senior water rights holders and has agreed to give up 4,000 afy of the 18,000 afy entitlement. This means that New Mexico is entitled to 14,000 afy or 140,000 af over the course of ten years (Siwik 2004).

Beginning in 2012, the Lower Basin Development Fund will deposit $66 million into the New Mexico Unit Fund, over the course of ten years, to be administered by the Interstate Stream Commission.[1] Funds must meet a water supply demand and be approved by the NMISC in consultation with the Southwest New Mexico Water Planning Group. Expenditures may include necessary costs associated with planning and environmental compliance activities, and environmental mitigation and restoration resulting from related water development projects. Funding above the $66 million (not to exceed the $128 million) is available for a project or activity, such as a dam, that would develop additional water for New Mexico in the Gila Basin (NMISC 2006).

Additionally, the AWSA permits that the funding can support water development projects such as hydrologic studies or mitigation, restoration and/or environmental measures, and that the work does not have to relate to the state's Central Arizona Project (CAP) allocation (Arizona Water Resources 2004).[2] This distinction is a key factor to the recommendations that I make, in that funding can be used to mitigate already existing damage or to improve environmental conditions.

[1] The Lower Basin Development Fund is funded through Central Arizona Project (CAP) repayments, redirected from the U.S. Treasury (Arizona Water Resource Newsletter 2004).
[2] For more information on the Central Arizona Project (CAP), see the 2004 Arizona Water Resource Newsletter.

The NMISC enacted a policy to guide funding and uses of water resources in the Gila basin (SWCA 2006). The policy acknowledges the environmental, traditional and cultural uniqueness of the Gila River.

> "The Interstate Stream Commission recognizes the unique and valuable ecology of the Gila Basin. In considering any proposal for water utilization under the Section 212 of the Arizona Water Settlements Act, the Commission will apply the best available science to fully assess and mitigate the ecological impacts on Southwest New Mexico, Gila River, its tributaries and associated riparian corridors, while also considering the historic uses of and future demands for water in the basin and the traditions, cultures and customs affecting those uses"(NMISC 2006).

The State of New Mexico must provide notice to the Secretary of the Interior in writing no later than December 31, 2014, stating if and how New Mexico wishes to utilize the benefits under the AWSA. Notice to the Secretary must be based on sound science and reasoning. The Act requires full compliance with all provisions of federal environmental mandates including the National Environmental Policy Act and the Endangered Species Act. The upper Gila Basin has several federally listed species. The impacts on state and federally listed species, resulting from any use of the funds or development of the water that New Mexico gained in the AWSA is a critical factor in determining how to utilize the benefits (NMISC 2006).

The Commission is committed to public involvement to move the planning process forward. New Mexico Governor Richardson stated that the NMISC must implement a planning and decision-making process that includes a full and inclusive public outreach program (OSE 2006). The NMISC is using a collaborative planning process to evaluate the potential water development scenarios under the Consumptive Use Forebearance Agreement (CUFA) and the 2004 AWSA (SWCA 2006). The public involvement component of this project is intended to include all stakeholders in the

Upper Gila River Basin. The NMISC in consultation with the Southwest New Mexico Water Planning Board, the citizens of southwest New Mexico and other interested parties will make decisions regarding how to allocate the funding and use the water, in compliance with CUFA (Tidwell and Passell 2006). The goal of the planning and decision making process is to provide the citizens of Southwestern New Mexico with the information and data they need to provide informed input to the Southwest New Mexico Water Planning Board (NMISC 2006).

These additional water rights present both opportunities and threats to the state, environment, economy and the Gila River itself. While the aforementioned stakeholders are considering many alternatives for water development, I examine three options for dedicating these water rights to instream flows on the Gila River. Instream flows are defined as "the water flowing in a stream channel" (Instream Flow Council 2002). While all three options ensure that water from the Gila River is not diverted in New Mexico, they each use different methods to achieve this result.

The Gila River is the last wild river in New Mexico, which means it is the last main stem, free flowing river in the state, and one of the last in the southwestern United States. Although it has several small agricultural diversions and one mining diversion, there are no major diversions or dams. The river is largely perennial from its source to the New Mexico / Arizona state border and is characterized by seasonal peaks and unregulated flow (Rice 2005). Recognizing the central role rivers play in ecosystems is instrumental in creating effective environmental policy. The state of New Mexico must consider water management, environmental stewardship, consumption and growth in determining how to use the water.

Many river advocacy groups and communities have organized and expressed commitment to continue to organize and plan to protect and keep wild rivers wild (Grossman 2002). One such group, The Gila Conservation Coalition (GCC) (also referred to as the Coaltion), motivated by threats to the Gila River's unique status as an [unprotected] wild river, re-emerged after a twenty-two year hiatus. The Coalition first came together in 1984 to stop the proposed Hooker and Conner dams on the Gila River.[3] The GCC organized community members to become more involved in the decision-making process and to protect the Gila River from water development projects that will adversely affect the river and watershed. The actions of the Coalition influenced the Commission to implement an amendment that would not limit New Mexico Unit Funds to a specific water development project and would allow local communities, through the Southwest New Mexico Water Planning Group, to decide how this federal funding is applied to regional water management priorities (Siwik 2004).

The actions of Gila Conservation Coalition reflect a larger national trend. During the past two decades, rivers throughout the United States have begun to experience a renaissance as communities and organizations actively work to protect and restore rivers. As the ecological importance of rivers becomes increasingly recognized and understood, communities, local, state and federal governments will have more tools to work towards reclamation and restoration (Grossman 2002).

C. Goals of the Professional Project

In this professional project, I identify and analyze how the state of New Mexico can use water rights acquired from the Arizona Water Settlements Act for instream flows

[3] For more information on the Hooker and Conner proposed dams, see: www.gilaconservationcoalition.org

and how this use of water will benefit the environment, society, economy and the Gila River. In order for any option to succeed, it must be legally and economically viable, as well as environmentally sound. The proposed alternatives should meet the criteria of the Arizona Water Settlements Act 2004 (AWSA), as well as preserve the natural character of the Gila River and the ecosystem it supports.

The options I provide improve environmental conditions, in particular riparian habitat conditions for endangered species. Additionally, I demonstrate that future water demands based on population projections for residents of Catron, Grant, Hidalgo and Luna counties can be met with already existing water supplies in the Gila River. Furthermore, I show how these alternatives are cost effective, an essential factor since the project has a limited source of funding.

If the project were to exceed the AWSA funding, local taxpayers would be responsible for paying the remainder of the cost for this project, with the burden falling on local economically distressed communities (Siwik 2004). The average per capita income in dollars per year in the year 2001 was $14,003 for Catron County, $18,955 for Grant County, $17,258 for Hidalgo County and $15,656 for Luna County (NMED 2003 cited in DB Stephens 2005). Currently, there is no alternative commercial, state or federal funding dedicated to this project if the initial funding does not meet the cost of this project.

D. Overview of Paper

In this paper I provide information and analysis to explain and support how New Mexico should use the water rights granted from the AWSA as instream flows. Chapter one describes my research question and planning framework, the opportunities presented

by the 2004 Arizona Water Settlements Act, and the goals and methodology that I use in this project. Chapter two describes the Gila River watershed in terms of the history of the Gila National Forest and Wilderness Area, habitat, geography and ecology, hydrology, and riparian conditions and human impacts on the watershed. Chapter three discusses the obstacles associated with instream flows based on traditional western water law, economic methods for evaluating instream flows and challenges to implementation.

Chapter four identifies three options for dedicating AWSA water to instream flow water rights. Option one uses the private market for the sale, lease and transfer of water rights to instream flows. Option two leases the water to Arizona. Option three dedicates the water rights to instream flows, not allowing them to be diverted, bought or sold under any circumstances, to meet the environmental needs of federally listed endangered and threatened species and other non-listed species.

Chapter five analyzes alternatives to these options based on economic, legal, and environmental issues. I provide an analysis of the water supply and demand in the Gila Region and supporting arguments for using the AWSA water rights as instream flows. In Chapter six, I make recommendations for using a combination of alternatives based on the analysis. Also, I present my recommendations for spending the federal funding granted with the AWSA. Finally, in the last chapter, I summarize the important themes of the paper and present ideas for future research.

E. Methodology

A comparative analysis was the primary method of research for this project. I used case studies from other western states to demonstrate how instream flow programs have been effective in other places. I spoke with many different stakeholders involved in

the AWSA planning process via phone conversations, email correspondence, and personal meetings to gather information. I also attended water-planning meetings in Southwestern New Mexico, met with Peter Litchy the Nature Conservancy and Dutch Salmon, the chairman of the Gila Conservation Coalition, to discuss the current issues and how these organizations are involved with this project. I have also been in communication with Allyson Siwik, the director of Gila Conservation Coalition, who is actively involved in the planning process and frequently writes about current issues, Professor Denise Fort, Esq. who is involved in Gila River water development planning to provide legal clarification, Marilyn Meyers, senior biologist at the U.S. Fish and Wildlife Service, to learn which species would be most affected by changes in flows on the Gila River, and Charles Jackson, the Water Master for the Gila Region to learn more about water rights and uses on the Gila River.

In order to interpret the economic benefits of instream flows, I used both the Contingent Value Method (CVM) and the Travel Cost Method (TCM) for economic analysis. The economic analysis is an important component of each option as it provides a method for translating environmental values into economic values.

I compared the amount of water used in the Gila Region to the amount of water in the Gila River. I gathered data from the USGS gaging station at Redrock to find the average flows in cubic feet per second (cfs) for the past twenty years in both monthly and yearly periods. Then I referred to the Southwest New Mexico Regional Water Plan to find out how much water is currently being used and the projected water use for the years 2010, 2020, 2030 and 2040. These estimates account for withdrawal, but not return flows, and do not represent the depletion. Being that agricultural uses have the greatest

withdrawal and return flows, I wanted to determine what was going to be depleted in the future. I used a ratio of 3:1 based on past water use records to determine that in the future for every 3 acre-feet of water withdrawn, 1 acre-foot was returned.

Next, I looked at the monthly averages at the Redrock gage to determine what percentage of the yearly average each month accounted for. Using these percentages, I divided the acre-feet into monthly averages and then converted it to cubic feet per second by month. I arrived at this method because the Gila River has large seasonal fluctuations because it is not dammed. I estimated the quantity of water in the river in the future and then compared this number to the flows required to maintain fish habitat. For the majority of the year, these flows requirements to maintain "good" fish habitat.

CHAPTER 2: THE GILA RIVER WATERSHED

A. History of Gila National Forest and Wilderness Area

For most of a century, human presence on the upper stretches of the Gila has been relatively benign. The Gila River flows through a landscape that was designated as a Forest Reserve in 1899 and then became the country's first national wilderness area (Soles 2003). The Gila Wilderness Area was created in 1924 by executive order from the U.S. Secretary of Agriculture (USDA 2003).

Aldo Leopold, one of the country's foremost wilderness philosophers and former employee of the Forest Service, persistently lobbied for the protection of the Gila Wilderness area believing that the Gila Wilderness Area should be preserved for its natural character and beauty (New Mexico Wild 2006). His vision for the Gila Wilderness area is exemplified by his strong conservation ethic in this quote that is said to come from one of his hunting trips in the Gila National Forest.

> "We reached the old wolf in time to watch a fierce green fire dying in her eyes. I realized then, and have known ever since, that there was something new to me in those eyes. In those eyes ... something known only to her and the mountain. I was young then, and full of trigger-itch; I thought that because fewer wolves meant more deer that no wolves would mean hunters' paradise. But after seeing the green fire die, I sensed that neither wolf nor mountain would agree with such view" (Leopold 1949).

Originally the wilderness area encompassed 775,000 acres, including all of the land to the north and east that is now located in the Aldo Leopold Wilderness and including the majority of the Black Range. The two wilderness areas were separated in 1933 after an administrative road was built in North Star Canyon. Since then other changes in boundaries and acreage have occurred to create the present wilderness area (New Mexico Wild 2006).

B. Sense of place

Popular theory says that the word “Gila” comes from a Spanish contraction of the Yuma Indian word hah-quah-sa-eel, meaning “running water which is salty” (USDA 2003). Throughout history, the Mogollon and Apache Indians, Spaniards, Mexicans, ranchers, prospectors and miners have lived in or near the Gila National Forest (USDA 2003). As long as the United States has been a country, the communities in the Gila Region have had a relationship with a protected wilderness area longer than any other community in the country.

The Gila River is central to the Gila Wilderness Area, which is instrumental to the identity of the southwestern New Mexico region. It is easily accessible from the four counties within the region. The Gila Wilderness area is home to innumerable plant and animal species, and is renowned for bird watching. The Gila River is vital to the biodiversity of this wilderness area. Changing the way its managed will change the composition and aesthetic of the river’s character (New Mexico Wild 2006).

B. Habitat

The merging of the Chihuahuan, Sonoran and Southern Rocky eco-regions, as well as the vertical change from desert shrub to sub alpine forest, have created a diverse habitat that supports unique communities of flora and fauna. The Gila River supports the densest population of non-colonial breeding birds in United States. This area has the best remaining bird habitat in the lower Colorado River basin with the greatest diversity of raptors and the largest number of endangered threatened birds species in the basin. The Upper Gila watershed is the only watershed in New Mexico that still has all of its native fish because of its relatively natural flow regime. This watershed sustains over 25

federally and state listed endangered and threatened species, including the peregrine falcon, Mexican spotted owl, spikedace and loach minnow. One of the largest populations of endangered southwestern willow flycatchers in the world is located in the Gila Cliff Valley. The Gila River's natural flow regime, characterized by its "flashiness" due to late winter and early spring floods, supports one of the best native cottonwood willow riparian habitat in the southwestern United States" (Rice 2005).

C. Geography and Ecology of the Gila River Watershed

The Gila River and its tributaries form one of the most important river systems in the southwestern heartland, draining an area of 250,000 square miles, larger than the country of France. The watershed includes 2832 square miles, and is located within Grant and Catron counties in southwestern New Mexico (Upper Gila Watershed Alliance no date available).

The Gila National Forest encompasses 3.3 million acres, which includes the Gila Wilderness area, the largest protected wilderness area in the lower 48 states (Rice 2005). The diversity and beauty of the Gila is seen in its rugged mountains, deep canyons, meadows, and semi-arid desert country. Elevations range from 4,200 to 10,900 feet and include four of the six life zones (USDA 2003). In western New Mexico, the Gila River originates from springs in the high elevations of the Mogollon and Black Mountains, at 10,000 feet in altitude. Water from these springs mixes with snowmelt in mountain streams, which coalesce at lower elevation of 6000 to 7000 feet in elevation, and then disperse into the three forks of the Gila River (USGS 1923 cited in Soles 2003).

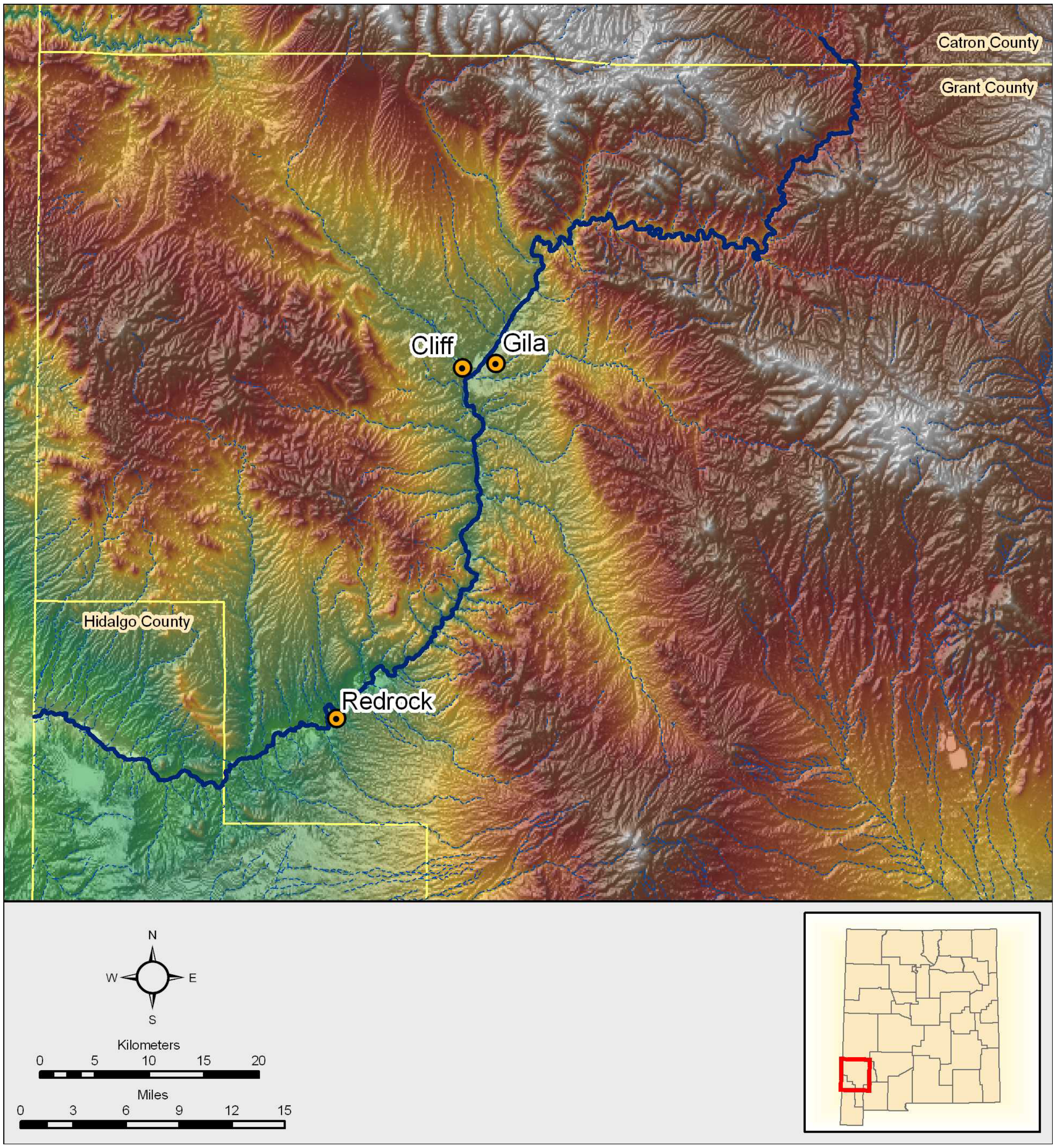

Figure 1. Gila River, D. St. Germain, 2006

Beginning in Catron County, immediately west of the Continental Divide in the heart of the Gila Wilderness Area, the Gila River flows through the National Forest and into high canyon walls of the Middle Box, near Redrock New Mexico, where it leaves the Forest Reserve at a 90 degree turn to the south, nine miles upstream from the town of Gila. There is a USGS water stage recording gaging station bolted to the canyon wall, which is designated at the "Gila" gagesite, number 09430500. Almost continuous records

of discharge have been collected at or near this site since 1928. Elevation at the gage site is 4655 feet above sea level and the watershed encompasses 1864 square miles at this point. The river is perennial at the gagesite, and the seasonal low flow during the drier months is generally around 40 to 50 cfs (USGS 2003 cited in SWCA 2006). The mean annual discharge is 195 cfs (USGS 2006).

The next 14 miles flow through a slightly wider alluvial valley and then it enters the Gila Riparian Preserve, a property managed by The Nature Conservancy (TNC) and extends along this “box” for a more than a mile. Downstream the river crosses one more mile of National Forest before entering a checkerboard of private and TNC owned lands in the Gila Valley proper, flowing past the tiny towns of Gila, Cliff, and Riverside. The Gila Valley is relatively small, less than two miles across at its widest point and about 14 miles long (Soles 2003).

The Gila River flows southwest for approximately 150 miles to Arizona, where it crosses the state border and joins the Colorado River near Yuma, Arizona (Upper Gila Watershed Alliance nd). The 20-year average annual flow at gage near Redrock is 262 cfs and 281 cfs at the downstream gage near Virden (USGS 2006).

About 81% of the watershed is publicly owned, the majority of it by the U.S. Forest Service, with the remaining 19% in private ownership (Upper Gila Watershed Alliance no date). Phelps Dodge Corporation is the predominant private landholder in the river valley, with most of its land being located near Gila and Cliff, New Mexico. There are 230 households within the watershed, according to 1990 census data. Silver City, the closest town of significant size outside of the Gila watershed and is east of the continental divide.

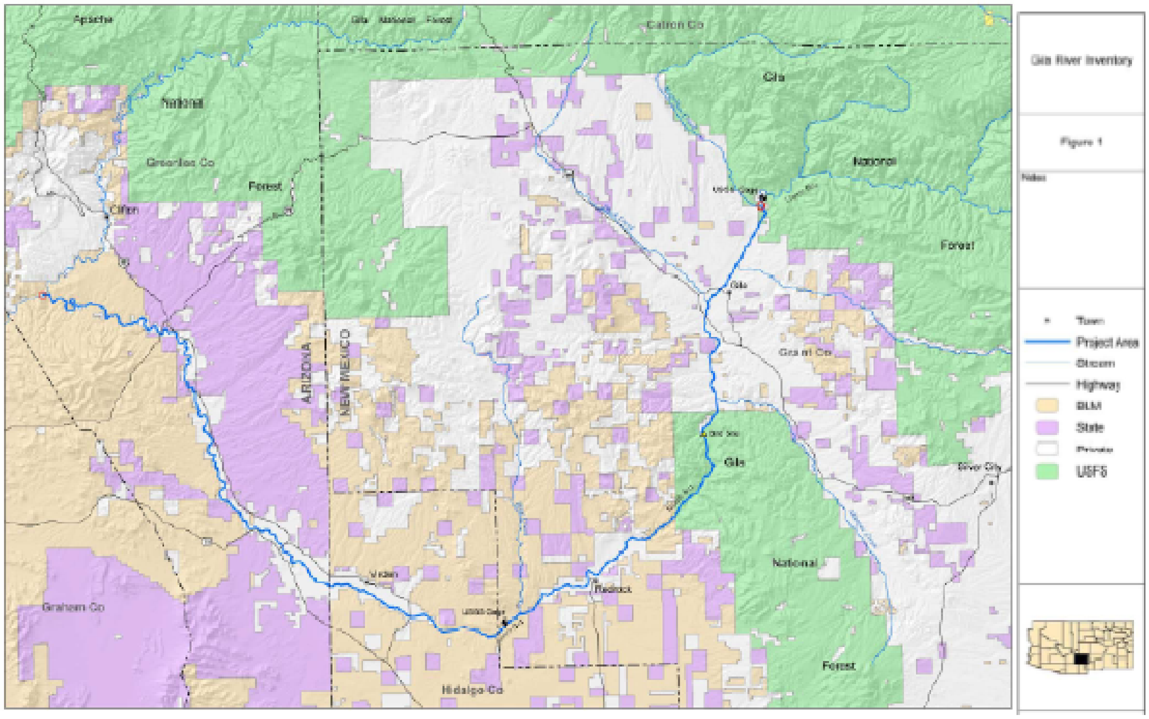

Figure 2. Gila River & Land Ownership, Upper Gila Ecological Conditions Analysis, SWCA 2006

D. Human Impacts: Grazing, Wildfire and Timber Harvesting

In the late 1800s and early 1900s, livestock grazing was uncontrolled and unmanaged throughout most of the watersheds in the Upper Gila Basin and as a result, most of the landscape was denuded of vegetation (Rixon 1905; Duce 1918; Leopold 1921; Leopold 1924; Ohmart 1996 cited in FWS 2006). Intensive livestock grazing increases soil compaction, decreases infiltration rates, increases runoff, changes vegetative species composition, decreases riparian vegetation, increases instream sedimentation, increases stream water temperature, decreases fish populations, and changes channel form (Meehan and Platts 1978; Kaufman and Kruger 1984; Schulz and Leininger 1990; Platts 1991; Fleischner 1994; Ohmart 1996 cited in USFWS 2006).

As a consequence, streams are more apt to experience flood events during monsoons because water will run off quickly instead of soaking into the ground, negatively affecting riparian and aquatic habitat. These stream reaches are more likely to

become intermittent or dry in September or October due to less groundwater recharge because of increased levels of run off (Platts 1991; Ohmart 1996 cited in USFWS 2006). The Forest Service manages livestock grazing more carefully now, resulting in less impact to streams in the watershed. Improved grazing management policies have reduced livestock access to streams (USFWS 2006).

Severe wildfires capable of decimating or extirpating fish populations are a relatively new phenomenon. They result from fire suppression and the cumulative effects of historical or overly intensive grazing, which generally leads to the removal of fine fuels needed to carry fire (Madany and West 1983; Savage and Swetnam 1990; Swetnam 1990; Touchan et al 1995; Swetnam and Baisan 1996; Belsky and Blumenthal 1997; Gresswell 1999), as well as the failure to use forestry management practices to reduce fuel loads (USFWS 2006). Historic wildfires were cool-burning understory fires happening in three to seven year intervals in Ponderosa Pine and five to 20 years in mixed conifer (Swetnam and Dietrich 1985 cited in USFWS 2006). Copper (1960) concluded that prior to the 1950s, crown fires were extremely rare or non-existent in the region (S. Gonzales; U.S, Fish and Wildlife Service, in litt, 2004 cited in FWS 2006).

In 2003, over 200,000 acres burned in the Gila National Forest (S. Gonzales; U.S, Fish and Wildlife Service, in litt, 2004 cited in FWS 2006). Increases in water temperature occur when the riparian vegetation canopy is removed by fire and the stream is directly exposed to sunlight. Increases in water temperature and sedimentation can also impact aquatic invertebrates, changing species composition and reducing the number in a population (USFWS 2006). The Forest Service has greatly reduced livestock grazing and timber harvesting over time and it is expected that the livestock practices that have been

implemented will remain in place (A. Telles cited in U.S. Forest Service; Gila National Forest in litt 2003 cited in USFWS 2006).

Logging activities in the early to mid 1900s are the most likely reason for major changes in the watershed characteristics and stream morphology (Chamberlin et al 1991 cited in FWS 2006). Rixon (1905) reported that several small timber mills were in operation in numerous canyons of the upper Gila River drainage. Early logging activities were concentrated at canyon bottoms, usually in those with perennial streams. Tree removal along perennial streams in historical range of the Gila Trout most likely altered the water temperature regimes, sediment loading, back stability, and availability of large woody debris. Today, timber harvest in not allowed in wilderness or primitive areas and there are no plans for timber harvest near other streams that have Gila Trout (A Telles cited in U.S. Forest Service litt. 2003 cited in USFWS 2006).

By the early 1900s, much of the Gila River corridor had been developed into pastures and agricultural fields, severely reduced, multi-aged riparian forests persisted, particularly in the upper reaches of the river where there were no major impoundment structures or significant alterations to the natural hydrograph. By contrast, wetlands and cienega habitats, which had been common in the 1880s near confluences with tributaries, had disappeared (McNamee 1994 cited in SWCA 2006).

E. Hydrology

The Upper Gila River does not contain any significant impoundments or flood control structures within the channel. As a result, the Gila River system experiences mostly natural flooding dynamics. The frequency of flooding varies in magnitude, causes primarily by rains from fall and winter storm systems. Storms that produce extreme

floods are widespread and generally cover the majority of the Upper Gila River Basin. The largest magnitude floods occur in the fall and winter and are predominately from rainfall. The largest floods, greater than 12,000 cfs, have occurred in 1891, 1907, 1941, 1949, 1972, 1983, 1984, 1988, 1993, 1994 and 1997 (USGS 2006 cited in SWCA 2006)

F. Agriculture and Water Withdrawals

Large-scale agriculture has never been practiced in the Gila Valley. The small irrigation diversions that supply farmers and ranchers with water for their fields are located in the upper reaches along the mainstem of the Gila River (Soles 2003). Water is withdrawn throughout the year to irrigate fields, except during the severely cold winter months. Current water withdrawals often result in channel drying in several reaches throughout the Gila Cliff Valley, within the Middle Box, and downstream of the Middle Box to the confluence with the San Francisco River, especially during the summer months and during drought conditions. When river water is not available, due to low water levels, groundwater is pumped from local and private wells to meet irrigation demands (Woodrow cited in SWCA 2006).

The Gila River channel widens and constricts in response to flooding and vegetation, as is the case for most southwestern streams and rivers. Channel narrowing is accelerated by encroachment into the active channel by agriculture and non-native riparian vegetation, while channel widening is a response to increases in frequency and magnitude of annual peak flows (Julien et al 2005 cited in SWCA 2006).

G. Riparian Conditions in Gila River Region

Montgomery et al. (1985), found that habitat along the Gila River corridor consisted of 13% riparian forests and 87% strands (narrow strips of riparian trees

surrounding the edges of agricultural fields) and abandoned agricultural fields. Generally the riparian corridor contained cottonwoods, willows, sycamore, boxelder, walnut, hackberry and mesquite (Rixon 1905; McNamee 1994) Among the riparian forests, 71% were cottonwood-willow dominated forests, 14% were boxelder dominated forests along the river channel, 10% were walnut dominated forests at the edges of the floodplain, and 5% were sycamore dominated forests restricted to the area near Mogollon Creek. During most of the 1900s, there was little change to the species composition of the riparian areas. Agricultural lands were most abundant along the river though most fields were abandoned and grew Russian thistle and sunflower. Stands of riparian trees were devoid of other vegetation except for some isolated patches of trees along river bends (Montgomery et al 1985 cited in SWCA 2006).

The riparian communities in the upper Gila River have remained relatively unchanged since the early 1900s. However, non-native salt cedar is now locally abundant (Whiteman 2006 cited in SWCA 2006). These riparian areas are important to terrestrial and aquatic species, demonstrated by the fact that this habitat supports the highest diversity and abundance of wildlife in the area. The value of the riparian area relative to their geographical limitation is disproportional, but relatively common (Montgomery et al 1985). Many of the species in the region are listed by state or federal agencies as threatened or endangered, and they depend on riparian habitats for survival (SWCA 2006).

Ecologists familiar with the southwestern United States recognize the essential role of riparian areas within the region. They provide disproportionate amounts of total forage production, cover, and water in desert or semi-arid climates, but typically only

account for a small percentage (less than 1%) of the land area within semi-arid regions (Apple 1985 cited in Soles 2003). The riparian areas provide habitat for hundreds of species that either occupy them year round, or use them as a stopover point in migratory paths. Complex biological, geomorphic, and hydrologic interactions are created and sustained by these systems and their consequent diversity is well known (Auble, Friedman, & Scott 1994; Brady, Patton & Paxon 1985; Bren 1993; Lamb and Lord 1992 cited in Soles 2003). A striking overall net loss in riparian areas in the southwest has occurred during the past two centuries and more is in danger of being lost (Kauffman et al. 1997; Rojo et al. 1998; Stromberg, Pattern & Richter 1991 cited in Soles 2003).

CHAPTER 3: CHALLENGES OF SHIFTING WATER POLICY PARADIGMS

A. Changing Perspective

Western water law is established through prior appropriations, where the governing principle is "use it or lose it." Under the "use it or lose it" principle, conservation of water has historically been considered a waste of water, and many traditional western water users consider the protection of instream flows unthinkable. Not only is water not being diverted and put to "use," but also diversion is strictly prohibited. Many westerners do not support instream flows because this concept is radically different from the roots of traditional western water policy. This perspective is beginning to change, but that change doesn't come easily. As Mark Twain said "Whiskey is for drinking. Water is for fighting over."

The 1997 Western States Water Council of the Western Governor's Association summarized the member states' responses to a survey regarding their most significant water problems. The problem of "providing supplies for growing consumptive demands was ranked by all states as the number one problem and meeting expanding environmental needs, including instream needs, was identified by all but two states as the number two problem" (Western States Water Council 1997).

1. New Mexico: the Last Western State to Recognize Instream Flows

Prior to 1998, every state throughout the western U.S., except New Mexico, had legally recognized instream flows. While other states were tackling the issues of how to implement instream flows, New Mexico was still deciding if instream flows should legally recognized. It is rare that instream uses are represented in water management decisions due to the strong opposition posed by agricultural interests, demands from

municipalities and incomplete statutory protection of the environment (Fort 2000). New Mexico was the last western state to recognize instream flow rights as a beneficial water use (OSE 2001). New Mexico didn't encourage instream flow rights due to contentious debates around extreme aridity, poverty, exclusive water establishment, and unique tensions related to the state's agricultural history and heritage (Fort 2000).

By law, all waters in the state of New Mexico are declared to be public and subject to appropriation for beneficial use (OSE 2001). The 1998 Attorney General's opinion stated that neither the New Mexico constitution nor the state statutes require diversion for a water right to be legitimate. Case law from other states with similar constitutional provisions noted that even where "the right to divert" was explicitly referenced in the constitution, courts found no constitutional requirement of the diversion (Fort 2000).

The state's framework for managing water can be adapted to serve evolving understandings of the role(s) water should play for society (Fort 2000). As a result of the state's recognition of instream flows as a beneficial use, policy makers have the tools to support river restoration and protection.

While there are many methods for establishing instream flows, the most common is the appropriation of a publicly or privately held water right, which the owner keeps in a stream or river rather than diverting it for agriculture or other traditional uses (Fort 2000). An important outcome of the state's recognition of instream flows was that it enabled federal agencies to develop additional strategies in protecting federally endangered species in New Mexico's rivers. Federal agencies that control water (through federal ownership, leases, and opportunities for purchase) may use their water rights for instream

flows. Changing the widely held belief that New Mexico prohibited instream flows enabled federal agencies to be more creative in using water rights for these practices and purposes (Fort 2000).

B. Economic Impact of Instream Flows

Instream flows provide important environmental and economic benefits. These flows support riparian habitat, which in turn support a host of aquatic and terrestrial species, as well as water quality benefits on the Gila River. I discuss the environmental benefits of instream flows further in chapter five. The economic benefits of instream flows are more widely dispersed, and result in multiple indirect benefits. For purposes of this project, I focus on the relationship between instream flows and income produced by recreation.

1. Instream Flows Generate Income in Recreation

The intangible value of free-flowing water in the western United States is important to many people, primarily because it is a scarce resource, and demand for it is increasing with growth and development. While spiritual and aesthetic values of instream flows are important to many people, the driving force that has compelled state legislators and administrators to initiate protective statutes and actions in recent years is the recognition of broad economic as well as intangible benefits free flowing water brings to a region (Shupe 1989).

When agriculture, mining and energy began to decline in activity during the 1980s in the western United States, the reliability and economic importance of the recreation and tourism industry became increasingly apparent to state policy makers.

These industries largely depend on water related activities, which means the value of instream flows in the west is significant to the overall economy (Shupe 1998).

Rivers also provide "recreation habitat" for human activities (Brown 1992). The quality and value of these resources are dependent on stream flow, both directly and indirectly (Brown 1992). Fishing, commercial rafting, boating and scenic waterways attract large numbers of people. Commercial fishing is highly dependent on the level of instream flows. According to the Fish and Wildlife Service in 1996, a national survey states that fishing generated $195,000,000 per year in New Mexico (Fort 2000). In 2005, nearly 20 million domestic travelers visited New Mexico in the first nine months, an increase of 11.6 percent compared to the previous year. New Mexico tourism is a $4.95 billion dollar per year industry (New Mexico Department of Tourism 2006). Millions of dollars in revenue are lost when diminished instream flows compromise river related activities. These losses debilitate local economies and disrupt businesses statewide. Furthermore, the loss of recreational opportunities also has a negative social value and detrimental effect on people who find enjoyment and release from urban tension in water based activities (Shupe 1989).

Natural environments, enhanced by streams and lakes, help attract new businesses looking to locate in areas where employees can enjoy a high quality of life (Shupe 1989). In turn, these businesses support the local economy and often provide employment opportunities to local residents. The recreation industry thrives on the development of new recreational activities in small towns in remote locations.

2. Economic Methods for Determining Value of Instream Flows

The values of instream flows are multi-faceted and often intangible, which is why it is difficult to translate a non-monetary value to a monetary value. While researchers have developed a variety of available methods for translating an environmental value into an economic value, I chose to use the Contingent Value Method (CVM) and Travel Cost Method (TCM) because these two methods are used more often than others when determining the economic benefits of recreation based on the condition of the environment (Hackett 2001).

A market value is the price a willing buyer would pay a willing seller in an arm's length transaction (Office of Real Property Services, no date available). Goods that are not readily bought and sold do not have a market and therefore have no market value. While water rights have a market value because they can be purchased and sold, water also has a value that the market does not capture. For example, the spiritual or scenic value of water has no market value. When water is diverted is has a market value, however when it is left instream it has no market.

Intangible environmental benefits fall into two categories, use and nonuse values. "The use value represents the utility enjoyed by people who directly use some aspect of the environment" (Hackett 2001). For instance, a bird sanctuary provides use value to those who birdwatch, or those who use the area as an open space. "Nonuse, also known as passive use value or existence value, reflects value that people assign to aspects of the natural environment that they care about but do not use in a commercial, recreational, or other manner" (Hackett 2001). For example, someone may value the existence of grizzly

bear habitat in Alaska, but have no interest in visiting this habitat. Existence values raise controversy because they are difficult to measure.

One type of non-use value is "option value," which is defined as "a willingness to pay for retaining an option to use an area or facility that would be difficult or impossible to replace and for which no close substitute is available. Such a demand may exist even though there is no current intention to use the area or facility in question and the option may never be exercised" (Henry 1974). Option value is applied when there is uncertainty over the ultimate environmental impact of a given activity or if it is irreversible. Preservation has option value because it allows time to learn about the outcomes, services, or impacts provided by the environment (Hackett 2001).

Using the water rights as instream flows will allow time to determine what the future water demands of the area will be. There would be no immediate action to change the river system at this time. This alternative provides "option value," or the value of holding an opportunity for the future, by not consuming it today. Also the quasi -option value, which is the value of gaining information by not taking action, could be employed (Chermak, lecture, April 4, 2006), allowing the state to gain a greater understanding of the water needs for both people and the environment in the area.

Survey research methods have been developed to measure non-use values. The CVM uses survey questions to elicit hypothetical responses regarding illingness-to-pay. Ciriacy-Wantrup (1974) was the first to propose CVM, but a Harvard doctoral student, Rob Davis, was the first to implement the CVM. In his dissertation, he attempted to value non-marketed aspects of the Maine woods, particularly hunting and recreational values. He compared the CVM to the Travel Cost Method (TCM), which is described below, and

arrived at similar valuations. Because CVMs are one of the few ways to determine nonuse values, CVM studies became very popular after a paper published by environmental economist John Krutilla (1967) on the "real" nature of existence and nonuse values (Hackett 2001). The guidelines used in a CVM survey are attached as appendix A.

3. Criticism of the CVM

Opinions of economists are divided about the usefulness of the CVM in measuring value and guiding policy. A key problem with the CVM according to Diamond and Hausman (1994), is the embedding effect. "Embedding" refers to the research methodology of comparing the value of a particular good, such as a mountain lake, to a more inclusive good, such as protecting an entire mountainous region that includes the lake. The embededness factor occurs when the willingness to pay (WTP) responses for a particular good (mountain lake) are equal to the more inclusive good (entire mountain range). The reason for this is that the individual responding has no particular preference or that the respondent doesn't consider the budget constraints that would occur from this action (Hackett 2001).

Another criticism is that the survey process itself creates values reported as empirical data, despite the fact that people may be just making something up when asked. While the premise of the CVM is that the standard economic view of rational humans is that individuals have a preexisting valuation map in their heads that ranks all of the possible choices available in contemporary markets, this assumption is not always accurate (Hackett 2001).

There is also the concern that there is potential for strategic bias in CVM survey data, which means that people may inflate their stated value because they do not have to pay. Another criticism is that the CVM cannot be verified. This statement is not always true, as survey responses can be replicated, compared with estimates from other sources and actual behavior (Hackett 2001).

4. Travel Cost Method

The Travel Cost Method (TCM) was first proposed in 1947 by economist Harold Hotelling in a letter to the U.S. Park Service, when he suggested that the full cost of visiting a park must include the cost of getting there. The TCM offers a way of measuring the value of a non-market recreational resource by using data on travel costs incurred by visitors using the area for recreational purposes. It only measures the economic benefits from recreational visitors, and ignores the existence values. The researchers must make a number of assumptions to generate a dollar-denominated measure of benefits. They must assume that the study area was the sole purpose of the trip, or conduct a survey to find out which portion of their travel is attributable to the study area (Hackett 2001).

An individual’s direct travel cost from his or her place of origin to the study area is the sum of the person’s share of direct transportation cost and an estimate of the value of time spent in transit. The Transportation Energy Data Book stated that in 1999 the average variable cost per mile of operating an automobile in the U.S. was $.10 (Oak Ridge National Laboratory cited in Hackett 2001). While today's average variable cost per mile is closer to .30 or higher (Wheeler, personal communication, October 2006) this method could be used to estimate the dollar amount a tourist would be willing to spend to visit the Gila River.

A limitation of the TCM is that multiple assumptions must be made to determine the value of recreational resource. Also it is difficult to measure recreational demand based on the TCM because it hard to know if people are on a single destination trip specifically to visit the area or if the person visits the area because it is conveniently located along their final destination route (Hackett 2001). Also, the marketing and advertising plays a role, which may result in undervaluing lesser-known and non-accessible wilderness areas.

5. Results of Case Study Using Both CVM and TCM

The relationship between instream flow quantity and recreation determines what (if any) types of recreational opportunities are available on different stretches of rivers. Several economic studies have estimated willingness to pay for recreation at different flow levels. These studies, reviewed by Loomis (1987) all indicate that recreational enthusiasts' willingness to pay increases with flow to a point and then (for most activities) decreases as flows rise above a critical level (Brown 1991). These findings were substantiated by studies conducted by Shelby and others in 1992. Nearly all of the studies indicate that no matter what the activity may be, fishing, boating, or streamside use, the flow positively contributes to the experience up to a certain level, but beyond that level additional flows detract from the experience (Brown 1991).

Brown (1991) discusses nine studies indicating the value of instream flow for recreation activities. These activities included fishing, boating, and general shoreline activities, such as picnicking. The studies used CVM or the TCM to determine the relationship between instream flows and money generated by recreational activities. The majority of the studies showed that the value of the flow reaches a peak, and then

decreases as the flow level continues to increase. Based on acre-foot estimates, the CVM and TCM studies showed that the marginal value of flow at times of low flow varied from less than $1 to $25 per acre-foot. This means that recreational enthusiasts value each additional acre-foot of water from $1 to $25 to augment relatively low flows during periods of recreational use. Higher values within the given range were generally found on smaller rivers, where an acre-foot has a greater relative impact. Hansen and Hallam's (1991) cross sectional analysis indicated that marginal values of flow for fish were below $10 per acre-foot in most regions of the country, but were considerably higher in certain regions, particularly the arid Southwest (Brown 1991).

6. Economic Impacts Associated with Scenic Beauty

Although it is known that a relationship between instream flows and peoples' willingness to pay for recreation exists, it is more difficult to determine peoples' willingness to pay for scenic beauty. Determining the value of leaving water from the Gila River in its riverbed for the sole reason of its intrinsic beauty is very difficult to do. Quantifying beauty is not easy because it is a qualitative value, not a commodity with an assigned market value. Furthermore, the value of beauty is subjective and will change depending on the viewer's perspective.

One of the economic studies reviewed by Loomis (1987) and conducted by Daubert and Young (1981) on the Cache La Poudre River in Northern Colorado was a unique study that focused on scenic beauty. Scenes were presented to observers in two different formats varying in the degree to which they tended to focus the observers' attention of the flow rate. All of the observers were presented scenes of the river on videotape. The video images included large differences in vegetation, topography, view

perspectives, depth of view, weather, as well as other features that depicting moving water. All of the participants were asked to rate the scenic beauty of the various sections of the river (Brown 1991).

The results showed that regardless of the presentation format, scenic beauty initially increases with increased flows to a point, and then decreases as flows continue to rise. This study indicates that instream flow quantity influences riparian scenic beauty and aesthetics in a way that mirrors recreation enthusiasts' willingness to pay (Brown 1991).

C. Challenges of Implementing Instream Flows

Even though environmental and economic values support instream flows, there are many challenges to implementing a system to protect them. According to Tarlock (1993), effective instream flow protection is based on public acceptance, economic rationality and science. States are struggling with the implementation, significant legal recognition, and political barriers associated with instream flows, which result in failure to restore and protect waterways throughout the arid west. While every western state has recognized the need to protect instream flows and has adopted various legal devices to do so, there are still several problems that arise when trying to implement instream flow programs. The problems that continue to constrain the implementation of instream flows are associated with science, money, and politics (Neuman 2000).

Whether the state, tribal, federal or private entities create instream flow programs, other water users regularly oppose them in New Mexico and throughout the west. For many opponents, there is no incentive or desire to allow a new interest group to share a

resource that historically has been controlled and managed for the benefit of a few (Fort 2000).

The most powerful and consistent stakeholder group opposed to instream flows in New Mexico has been agricultural interests. In New Mexico, as in other western states, irrigators own the majority of the water rights and consume about 90% of the water (Wilson 2003; Fort 2000). The water establishment in New Mexico is still dominated by conservative and traditional water users (Fort 2000).

Acequia associations throughout the state have been outspoken in their opposition to instream flows in recent years. Some of the opposition is based on the fear that new competitors for water will be able to purchase rights held by acequia members, thereby increasing the movement of water away from the community (Fort 2000). Opponents have raised the issue regarding the difficulty of administering instream rights, based on the differences between instream rights and other types of water rights (Fort 2000).

1. Science

Controversy arises out of determining the quantity of flow that is needed to support instream resources. In most western states, the amount of water protected is directly related to the amount of water needed by specific fish species. However, administrative officials use various models to determine the quantities needed, and there is little agreement over which approach is the best (Fort 2000).

There is not one widely accepted uniformly applied scientific methodology for evaluating the ecological value of instream flows (Gillilan and Brown 1997 cited in Neuman 2000). Federal Agencies prefer the Instream Flow Incremental Methodology (IFIM) (Nueman and Chapman 1999 cited in Nueman 2000). This method uses a

computer-modeling program to show the relationship between flow and habitat conditions. It is expensive to use, requires large quantities of data, and is time consuming. It may take years to complete an analysis for a single stream segment and ultimately offers a prediction based on a model.

Some states prefer to use methodologies they have devised. For example, in Oregon, state fish and wildlife officials use the Oregon Method, which is less expensive and a more site-specific alternative to the IFIM. None of these methods are widely accepted and all have been criticized (Gillilan and Brown 1997 cited in Nueman 2000). Not having a useful and credible scientific tool hampers the initial protection decisions, which would determine the quantity of water that should be included in an instream water right or minimum stream flow to accomplish the desired goal (for example, restoring fish habitat). Also post-evaluation of instream flows are challenging because it is difficult to determine if the desired benefits are being produced at the level necessary to show the required beneficial use under state law (Neuman 2000).

The absence of a well developed, universally accepted, scientific method for evaluating instream flows and the effects on habitat hampers any legal action taken to protect instream flows, as it may be contested in court. Until scientifically sound information is available, interest groups on all sides of the issues will continue to use the uncertainty factor to support their respective positions. Information is needed in many areas such as hydraulics, fish passage, groundwater / surface water connections and the interaction of quantity, quality, and temperature of water with habitat and life cycle needs (Neuman 2000).

There is also disagreement over the quantity of instream flow based on ethical values. Should the level maintain the optimum species production or ensure population survival? These issues are further complicated when the levels also need to dilute contaminants, promote recreation, maintain riparian habitat or transport sediment (Shupe 1989).

Another scientific problem is the lack of consistently applied measurement and reporting requirements for many water users in the western states. While the level of measurement varies widely from state to state, as well as within states, thousands of consumptive water users throughout the west do not have even rudimentary measurement technology. The lack of good data makes it very challenging to define and protect instream rights, minimum streamflow requirements, or the allocation of water for instream and out of stream water uses (Neuman 2000).

2. Economics

Money is another barrier to instream flow protection. The places most in need of instream flows, which are already compromised by limited or non-existent flows, are generally already over appropriated. This results in diminished water quality, aquatic life and esthetic and recreational values. Effective instream flow restoration will require the conversion of consumptive water rights senior to an instream flow program to be dedicated to instream flows (Nueman 2000). Most states recognize the ecological and economic benefits created by instream flows and have provided a vehicle for this conversion

One universal issue is no matter which valuation method is used; acquiring water rights for instream flows to meet the needs of the riparian ecosystem can be expensive. In

the Pacific Northwest, state run programs that acquire water rights for dedication to instream flows paid an average of $330 per acre-foot, and throughout the western United States, instream acquisition prices have been as high as $850 an acre-foot (Neuman and Chapman 1999 cited in Neuman). In California, the Bureau of Reclamation spent millions of dollars to acquire tens of thousands of acre-feet to support fish and wildlife, and Colorado spent an estimated $12 million in water rights transaction between the city of Boulder and the Colorado Water Conservation Board (Natural Resources Law Center 1997 cited in Neuman). Restoring depleted stream flows in the West using the market, acre-foot by acre-foot, will take billions of dollars (Neuman 2000). This highlights the need for innovative alternatives for direct public acquisition.

3. Politics

While scientific and economic barriers create challenges to implementing instream flows, the greatest hurdle is political resistance. Even if the legal framework exists to protect instream flows, nothing can guarantee a willing seller. Political barriers can prevent instream flow protection from taking place even if scientific and economic problems are resolved. The success of instream flow implementation is dependent on public acceptance. Now that instream flows are finally being recognized and protected at some level, an anti-instream backlash is developing (Neuman 2000). Anti-instream sentiment is common throughout the West and flares up when existing uses are threatened (Gillilan and Brown 1997, Fort 2000, Neuman 2000). For instance, in Oregon instream water rights laws have existed since 1987; however only junior water rights had been used for instream flows until 1993 (Neuman 2000). This exemplifies how much

power senior water right holders have and until they are willing to use their water rights for instream flows, it will be difficult to establish instream flows.

In 1993, the Oregon Water Trust was established as a non-profit corporation to acquire senior water rights in the market and convert them to instream rights, which is legal in Oregon. In every legislative session since the Oregon Water Trust was formed, there has been opposition to the water rights conversion program either in terms of proposed limitations or outright attempts to appeal the instream water rights law. Several prominent agricultural leaders and interest groups have vocalized their opposition to instream rights unless principles are specified (Neuman and Chapman 1999, Neuman 2000).

4. Senior vs. Junior Water Rights

The AWSA presents a unique opportunity to adjudicate the new water rights to instream flows, potentially eliminating traditional conflicts that arise between senior and junior water rights. Most statutes allowing for the creation of instream flow rights were passed within the last two decades, meaning any new water rights sanctioned under the laws will have relatively recent priority dates. Instream water rights with junior priority are limited to keeping the water instream only if the water was not already over-appropriated at the time the rights were recognized. In times of shortage, when ecological needs are the greatest, junior water rights will be trumped by senior water rights. In areas of longstanding over appropriation, which includes much of the arid West, junior instream rights are simply not good enough to help solve the problem of depleted flows. One of the most important tools for restoring flows is the conversion of senior consumptive rights to instream flows. States that do not promote the conversion of senior

consumptive rights to instream flow rights will have instream flows on paper, but not in river beds (Neuman 2000).

The enforcement of an instream flow is another source of contention because gaging stations are needed. In an effort to alleviate this problem, the state of Washington has installed a sophisticated satellite gaging system to transmit stream flow data via satellite to the enforcement agency, which then uses a toll free phone system to inform junior water rights users to curtail their diversions when instream flows are injured (Shupe 89).

CHAPTER 4: POLICY OPTIONS FOR INSTREAM FLOWS ON THE GILA RIVER

A. Introduction to the Options

The Gila River, the last untamed and un-dammed river in the state, and one of the last in the southwest, is irreplaceable. The AWSA presents an opportunity for the people of New Mexico to make an important decision regarding the management of the Gila River. This decision impacts not only how water is used in the Gila Region, but also the character of the river itself and the habitat it supports. Bunn (2006), states that the results of this decision may not be visible for years to come as it take a significant amount of time to determine the ecological response due to flow change, especially for vegetation (Murphy 2006)

Although there are several policy options for the use of the newly confirmed water rights on the Gila River, the three options I explore in this paper present opportunities to use the confirmed water rights from the AWSA for instream flows on the Gila River. I chose these three options because I consider them to be the most likely to succeed based on economics, environmental consequences, case studies, and circumstances specific to the Gila River.

Option 1 is to appropriate the water rights to private users and let the private market present opportunities to dedicate the water for instream flows through buying, selling and leasing. Option 2 is for New Mexico to lease the water rights to Arizona. Option 3 is for the state of New Mexico to withdraw the water rights from appropriations, and dedicate the AWSA water to instream flows. These water rights could not be bought, sold, leased or diverted.

Chapter 4 Policy Options for Instream Flows on the Gila River

The options presented in this paper are designed to complement the natural environment and demonstrate how the use of instream flows benefit the environment, society, economy, and the state of New Mexico. This chapter gives a brief overview into each option and chapter five discusses each option in greater detail.

As discussed in chapter 3, some parties will wish to leave the water in its natural channel for instream uses and by contrast, other parties will favor diverting the water from the river for out-of-stream uses. Traditionally rivers in the west are managed under the principle of "use it or lose it." Commentators have recognized two primary vehicles for maintaining instream flows given the requirements of a beneficial use system:

> "Water in natural watercourse can be removed from availability for some or all forms of appropriation by state action or federal law to preserve it for some future use or for instream flows. Protection of streamflows or lake levels for fish, wildlife, recreation, water quality and scenic beauty is accomplished in two ways. The waters can be "appropriated" for instream uses or can be considered withdrawn from appropriation so that the instream flows are preserved from depletion by private appropriators" (Getches 1997).

While options 1 and 3 are similar, there is an important distinction between them. Option 1 uses Getches' first method for protecting instream flows, meaning the water rights are appropriated and then dedicated to instream uses. In 1998, the New Mexico Attorney General concluded that insteam uses are legitimate beneficial uses under existing state law and that existing consumptive water rights can be transferred to instream purposes (Tex. Water Code Section 15.7031; Fort 2000 cited Nueman, 2000). Option 3 uses Getches' second method for protecting instream flows. The state will withdraw a defined quantity of water rights from appropriation so that instream flows are preserved from depletion by private appropriators.

B. Using the Private Market: Option 1

The state of New Mexico appropriates the water rights to private users. Various water users, including public and private organizations and individuals, would be able to buy, sell and lease these water rights for instream flows. Also, the state would enact a program where the state agrees that it will expedite or require only a notice of change (not a full application) in use and point of diversion for a sale or lease that moves water to instream flows (Nair, personal communication, September 2006). This would help alleviate bureaucratic dilemmas.

One of the principal benefits of a water market is that multiple voluntary acquisition methods can be used to reallocate water. A variety of lease, purchase and donation arrangements are all possible depending on the needs and interests of the buyer and the seller. In order to understand option 1, it is necessary to understand the difference between leasing and purchasing water rights, and the complexities of determining prices for either mechanism.

1.The Difference Between Leasing and Purchasing Water Rights

A lease of water rights involves the sale of the temporary right to use water, similar to renting an apartment where the tenant has the right to use the apartment but the landlord still owns the property. Within the limits of a water rights lease, the title to the water remains with the original owner and at the termination of the contract, possession and control of the water is returned to that owner. Several types of lease contracts are available. Regardless of the type of contract, return flow and the third party impairment issues are considered in the state administrative review process (Landry 1998). It is important to state that a lease is a beneficial use of water, and water rights owners who

lease those rights do not generally lose their water rights unless the lessee fails to use the water beneficially.

Purchasing water rights transfers the title including all benefits, costs and obligations, in perpetuity. Purchases are usually a response to long-term changes in the supply and demand conditions. Permanent purchases for instream flows are less frequent than leases (Landry 1998). When private organizations or individuals buy a water right, the quantity and priority date are being purchased.

2. The Value and Price of Water

In the western United States, the price of water is calculated by the market exchange of water rights. Throughout history farmers and miners have traded water rights to meet growing and changing water needs. Recently, cities and municipal water providers have entered the market. The majority of water rights markets have been limited to consumptive water uses. However, water markets in the western United States are making an important transformation. Market exchanges to provide free flowing water to improve and protect the environmental quality of streams and rivers are taking place (Landry 1998).

Water rights are valuable property rights in the West and it is unlikely that water rights holders will dedicate their water rights to instream flows for altruistic reasons. Monetary incentives will drive buyers and sellers to participate in the water market. While the market for purchasing or leasing water from senior right water holders for dedication to instream flows is growing, money is the obstacle that hinders this process (Willey and Diamant 1996; Gillilan and Brown 1997; Neuman and Chapman 1999 cited in Neuman 2000).

The key to making this option successful is determining what type of monetary incentive would convince a water rights holder to part with some of their water. The money issue is twofold: how is a value for instream flows established and then how is it possible to acquire enough money to purchase water for instream flows to make a difference (Neuman 2000)? How is fish habitat valued? How much is a fish worth? How much would one pay to place water in a stream (Neuman 2000)?

An irrigator can determine a value for water based on farm crop budget analysis or a comparison of sales of water, or the sale of land with or without water rights. Setting aside the fact that this computation is skewed because most irrigators do not pay directly for their water (Nueman 2000), even such imperfect measures are not available to calculate the value of water for instream flows. Those entering the market for instream flows will need to wait years to see the effect on the stream itself to determine if the desired benefits were achieved and, therefore, whether the price paid was appropriate (Nueman 2000).

Further complicating this picture is the fact that the price of water may be disconnected from its true value. Two market-based systems, a pricing system and a property rights system, are used to allocate and transfer water, as well as encourage efficient use. Both systems rely on prices as a method to move water to its highest monetary-valued use. However, price determination varies greatly between the two systems (Landry 1998).

In a pricing system, a central authority sets the market price. This price tells market participants to adjust their supply and demand for water accordingly. This system assumes that a central authority has complete information about water supply and demand and is able to adjust prices as market conditions change. In practice, these

authorities routinely fail to vary prices in response to changing economic conditions (Landry 1998).

In the property rights system, water is allocated at a price determined by the exchange of water rights for a limited amount of time (lease) or in perpetuity (purchase). Within this system, there is no central authority setting prices or other terms of transfers. After property rights are established in water, then markets are introduced and transfers of rights occur whenever the net private benefits are positive. Transferable property rights in water create economic incentives for parties who have the most knowledge about the value of water and its intended use and actively allocate water to the uses that provide the greatest level of profit. Trade continues until the marginal values are equal among water users. Therefore, economic gains can be captured through transactions with limited bureaucratic interference. Market prices emerge through the constant exchange of property rights between buyers and sellers (Landry 1998).

C. New Mexico Leases Its New Water Rights To Arizona: Option 2

In Option 2, New Mexico would lease its new water rights to Arizona. The state benefits from this option because it would leave water instream in New Mexico and generate income from the leasing agreement. Option 2 would lease Arizona additional water rights, beyond the 4,000 afy minimum bypass deliveries (water that must cross the Arizona state line) required by the AWSA.

In order for the leasing option to be viable, New Mexico must establish a leasing agreement with Arizona that clearly states the quantity that will be delivered and the cost for this water. The lease agreement needs to state whether the quantity of water will be a percentage of the total volume of water in the Gila River in any given year or a precise quantity of water measured in acre-feet. Additionally it needs to address what quantity

will be delivered during times of drought. A dispute resolution process needs to be determined prior to finalizing the leasing agreement so both states are aware of the process that will lead them to resolution as easily as possible in the event of a conflict.

Controversies and litigation over water use in the Gila River could be avoided by creating this type of agreement (Gila Conservation Coalition 2006). The Gila River is an interstate river that both New Mexico and Arizona have depended on throughout history. Arizona may be willing to enter this type of lease agreement because they have traditionally used water from the Gila River for many consumptive uses, primarily agriculture. As Arizona continues to experience a high rate of growth and development, the demand for water will increase.

Leases are frequently used in situations where one state can supply another state with water. In fact, the most common type of acquisition to obtain instream flow rights is the annual lease. In the western United States, between 1990 and 1997, a total of 127 leases were negotiated, 64 of the leases by the federal government. The majority of the agreements were short-term contracts, typically limited to one year. State organizations completed 50 and private organizations completed 13 leases (Landry 1998).

D. New Mexico Dedicates The Water Rights To Instream Flows: Option 3

New Mexico would withdraw its new water rights from appropriation, not allowing any entity to apply for the water rights and dedicate it to instream flows. The state would prohibit diverting, selling, or leasing the new water rights. The state would appropriate its water rights to instream flows on the Gila River to improve environmental conditions and habitat for endangered and threatened species, as well as non-listed species in the region. The state would also need to implement a monitoring program to

observe the results of this decision and the effect of instream flows on riparian conditions.

New Mexico's ecosystems are in an unhealthy state, as exhibited in overly dense woody vegetation, degradation of bio-diversity, and fragmentation of wildlife habitat (The New Mexico Forest and Watershed Health Planning Committee 2004). Consequently, New Mexico faces greater susceptibility to catastrophic wildfire and drought, compromised watersheds and decreased water supply, accelerated erosion and desertification. The state is implementing a wide range of efforts to reverse the symptoms of the problems that cause ecosystem decline (The New Mexico Forest and Watershed Health Planning Committee 2004). While these problems cannot be solved overnight, the state of New Mexico will start to resolve some of these ecological problems and improve watershed health by dedicating water to instream flows on the Gila River.

Throughout the West, states spend millions of dollars each year to restore ecosystems, yet the impact on ecosystem health is still just a fraction of what needs to be accomplished. Improving the condition of New Mexico's forests and watersheds will require a long-term commitment by all those who share a responsibility for restoring ecosystems (The New Mexico Forest and Watershed Health Planning Committee 2004).

Most western river basins have experienced water development projects that have enabled flood control, recreation, and hydropower and agricultural production. While these developments have helped to establish stable economies, they have caused adverse impacts to the natural environment and wildlife that live in these river basins. One of the key policy tools for habitat restoration is the management and planning of instream flows (Green 2001).

In summary, table 1 provides a brief overview of the pros and cons of the three options. While each option achieves the goal of using the AWSA water rights as instream flows, there are various impacts associated with each option.

Table 1. Pros and Cons of the Three Options

	Option 1:Private Market	Option 2: Lease to Arizona	Option 3: Dedicate to Instream Flows
Pros			
Environment	Support aquatic & terrestrial life	Support aquatic & terrestrial life	Support aquatic & terrestrial life
	In compliance with NEPA	In compliance with NEPA	In compliance with NEPA
	Improves capacity of stream bed to carry runoff & transport sediment	Improves capacity of stream bed to carry runoff & transport sediment	Improves capacity of stream bed to carry runoff & transport sediment
	Small quantities can have big impacts		
Economy	Low cost to implement	Low cost to implement	Low cost to implement
	Cheaper to prevent than mitigate E & T species	Cheaper to prevent than mitigate E & T species	Cheaper to prevent than mitigate E & T species
	Prices compete in water market	Prices compete in water market	
	Potential to increase income generated from recreation	Potential to increase income generated from recreation	Potential to increase income generated from recreation
		Directly generates income for the state	
Legal		Water rights protected from diversion	Water rights protected from diversion
		Less risk of non-delivery	
	Provides option to determine where water will be needed in future	Provides option to determine where water will be needed in future	Provides option to determine where water will be needed in future
Public Support	Potential for strong support if participants value the environment	Potential for public support bc public benefits without having to pay for instream flows	Potential for public acceptance bc the public benefits without having to pay for instream flows

Cons	Option 1	Option 2	Option 3
Economy	Low or no level of participation in water market	Cost of preparing and negotiating lease	Does not generate direct income for the state
	Does not generate direct income for the state		
	Too many people participate in water market and drive prices too high to be practical	Arizona may not want to lease water rights from NM	
Public Support	Principles go against "Use it or Lose it"	Principles go against "Use it or Lose it"	Principles go against "Use it or Lose it"
	Uncertainty if people will participate in market	Citizens of NM may want to use the water here in NM and not lease to AZ	Politically difficult - people may feel like there is too much gov't control
	Unwillingness to buy / lease water that should be protected by public trust doctrine		

CHAPTER 5: ANALYSIS OF THE OPTIONS

Finding economically feasible and environmentally sound options that allow New Mexico to meet its future water demands, while allowing the Gila River to remain a free flowing river is possible through the use of instream flows. The value of making an environmentally sound decision can have long lasting effects. High-quality thoughtful management choices are much less expensive than the cost of mitigating environmental problems created by poor natural resource decisions.

This chapter looks at the question will the existing resources provide the services and goods that will be needed to meet the future growth of the Gila Region? The data provided in Regional Water Plan regarding the available water supply and demand for the Gila Region was used to compare the present availability to the potential future demands.

A. Water Supply and Demand in the Gila Region

1. Population Growth

In order to plan for future water needs in New Mexico and the Southwest region, the degree of future population growth needs to be considered. Population projections for this region have been estimated based on interviews with selected community members, historical population trends, and from the University of New Mexico Bureau of Business and Economic Research (DB Stephens 2005).

According to the Regional Water Plan, in the low growth rate scenario for the Gila Region, which includes the four counties of Catron, Grant, Hidalgo and Luna, the population growth rate estimates a change from 65,768 people to 79,529 people by 2040, representing a 20% growth rate (BBER cited DB Stephens 2005). In the high growth rate scenario the population will increase from 65,768 to 103, 882 people representing a 57% increase in the region (BBER cited DB Stephens 2005). Current statistics addressing

population in each county in the southwestern region of New Mexico were assembled from the New Mexico Economic Development website and are summarized in the table below (BBER cited 2005).

Table 2. Estimated Population Growth from 2000 – 2040 in the Southwest New Mexico Water Planning Region (Bureau of Business and Economic Research cited in DB Stephens 2005)

County	Population (2000)	Growth Projection Rate	Growth Description	Estimated Population 2010	2020	2030	2040
Catron	**3,567**	**Low**	**No growth or decline**	**3,567**	**3,567**	**3,567**	**3,567**
		High	**Slow growth**	**3,999**	**4,233**	**4,288**	**4,336**
Grant	**31,083**	**Low**	**Initial decline followed by moderate growth**	**29,563**	**31,417**	**32,958**	**34,335**
		High	**Initial decline followed by higher growth**	**29,563**	**32,656**	**36,073**	**39,847**
Hidalgo	**5,929**	**Low**	**Increasingly negative growth**	**5,800**	**5,623**	**5,380**	**5,117**
		High	**Initial decline followed by no growth or decline**	**6,720**	**7,085**	**7,120**	**7,127**
Luna	**25,189**	**Low**	**Moderate Growth**	**28,493**	**31,598**	**34,253**	**36,510**
		High	**Significant Growth**	**32,181**	**39,499**	**46,339**	**52,572**
Total	**65, 768**	**Low**	**Sum of low Population Projections for 4 counties**	**67,423**	**72,205**	**76,158**	**79,529**
		High	**Sum of high Population Projections for 4 counties**	**72,463**	**83,473**	**93,820**	**103, 882**

2. Trends in Water Use

In Catron County, irrigated agriculture has used and continues to use the largest amount of water, representing 81% of water consumption. Changes in irrigated agriculture have a greater impact on water consumption than changes in population. Municipal and commercial sectors consume very little water in Catron County. The largest community is Reserve, with a population of 387 residents (2005).

Mining has historically used, and continues to use the largest amount of water in Grant County, consuming 62%, followed by irrigated agriculture, which accounts for 23%. Water use in mining operations fluctuates with the minerals market, and due to the recent decrease in the world copper market prices, Phelps Dodge Mining Company has significantly curtailed the mining operations near Silver City (DB Stephens 2005).

In Hidalgo County, the majority of water use is dedicated to irrigated agriculture. Trends in this sector will affect water use more than population growth. Water use for irrigated agriculture is expected to remain steady. In Luna County, irrigated agriculture consumes 95% of total water use. Luna County has the most irrigated land of any county in southwestern New Mexico. Like the other counties, trends in the irrigated agriculture sector will have more of an impact on water use than population growth. Substantial growth in the power generation sector is anticipated in the next 10 to 20 years, and Deming hosts one of the largest industrial parks in the region, which could potentially increase water use in the county depending on transportation access and land availability (DB Stephens 2005).

Given that the projected water use trends do not suggest radical changes in water consumption in the region, Rice (2004) suggests that there are alternative options to provide supplies of water without diverting surface water from the Gila River. According to Rice, the current and future water needs of this area can be met with existing water supplies. These needs can most likely be met with existing sources of groundwater and through the purchase of idle water rights in the area (Rice 2004). The population growth projections estimate that almost all of the future population growth will occur in the Mimbres Basin, which contains a plentiful source of groundwater, meaning that the

reasons to divert water from the Gila River are not compelling (Gila Conservation Coalition 2006).

3. Water Use in the Gila Region

The feasibility of all three options depends on the availability of adequate water supply to meet human needs. Development pressures have historically caused policy makers to prioritize water development projects or dams over ecological initiatives. However, as water management paradigms begin to shift, New Mexico could become a leader in choosing water management alternatives that meet human demands and simultaneously benefit the environment.

Information regarding water use in the Gila region came from the Office of the State Engineer's Water Use by Category in New Mexico Counties and River Basins, and Irrigated Acreage Report in 2000 (Wilson 2003). Depleted surface water accounts for the water withdrawn minus the return flows. Table three displays the total surface water depleted in the four southwestern counties affected by this decision.

Table 3. Total Surface Water Depleted in the Four Southwestern Counties of New Mexico in 2000

County	Catron	Grant	Hidalgo	Luna	Total Water Depleted (AFY) in 4 Counties
Total Water Depleted in each county (AFY)	**2902.82**	**4297.84**	**3991.49**	**10,507.89**	**21,699.15**

In order to determine if the water supply is meeting the current demand, the amount of water being used needs to be compared to the amount of existing water. The USGS gage data states that the 20-year average flow at the Red Rock gage is 190,257 afy. I chose to use this gage because it is most representative of the Gila River watershed

in New Mexico. It is located in the Gila Cliff valley, where the majority of the withdrawals and return flows occur. To determine the quantity of water in the Gila River, I subtracted the yearly amount depleted from the 20-year average annual flow. Using these numbers, I estimate that the average quantity of water in the Gila River in 2000 was about 168,557 afy based on the following information.

Table 4. Water in the Gila River (afy)

190, 257 afy (based on 20-year average at Red Rock gage)
- 21,700 afy (depleted surface water in Gila Region in 2000)
168, 557 afy water in the Gila River (in 2000)

The amount of available water (based on the depleted surface water subtracted from the 20 year average) will be compared to the projected water use in the southwestern counties to estimate if the supply of water will meet the future demand. The Regional Water Plan suggests projected water use, but these numbers are strictly the surface water withdrawals and do not account for return flows. It's important to include the return flows because agriculture is the largest user of water, but agricultural users also return the largest quantity of water to the river. For example, in 2000 in the Southwest Water Planning Region, irrigated surface water withdrawal was 76,645 afy, and the surface water return flow was 55,631 afy (Wilson et al 2003 cited in 2005).

Based on the numbers provided in Wilson's report (2003), I am using a ratio of 3:1 to estimate how much of the projected surface water use will be depleted from the Gila River. For every 3 af withdrawn, 1af is returned, meaning the depletion is 2 af. Table three shows total depletions based on the 3:1 ratio. The high growth rate scenario was used because it shows the most significant change to the Gila River.

Table 5. Projected Water Depletion in the Gila Region in High Growth Scenario (DB Stephens 2005)

Total depletions (AFY)				
Year	2010	2020	2030	2040
Catron	8,319.12	8,332.04	8,339.86	8,348.02
Grant	24,179.44	25173	25324	25489
Hidalgo	20,516.96	20,551.98	20,574.42	20,596.86
Luna	39,774.56	40,251.24	40,241.04	40,445.38
Total depletions (AFY)	92,790.08	96,328.26	96,509.32	96,919.26
20-yr. Average AFY in Gila River	190,257.11	190,257.11	190,257.11	190,257.11
Total depletions (AFY)	92,790.08	96,328.26	96,509.32	96,919.26
Difference (AFY) = what will be in river	**97,467**	**93,929**	**93,748**	**93,338**
Available AFY (2000)	**168, 557**	**168, 557**	**168, 557**	**168, 557**

While there is variation between years, the available water in the Gila River is decreasing. The next table shows the average monthly availability of water in the Gila Region based on future water use projections. The monthly fluctuation of water levels on the Gila River is significant because it is an unregulated river, without any large impoundments or dams. The seasonal changes have significant impact on fish habitat.

Using the projected available water that will be in the river in the high growth scenario for the year 2010 (based on table 5), I determined how much of that water would be flowing in the river each month in the year 2010. The projected monthly water levels (in acre-feet) were estimated based on the average monthly flows (in cfs) from the Red Rock gage over a 20-year period. Looking at the entire year, the monthly average was determined based on the percentage of water that was available each month, and divided by the yearly availability of water. I used this percentage to estimate what would be available in future years and then converted acre-feet to cfs. Then I used this information to estimate what the level of quality for fish habitat will be in future years.

Instream flow needs for fish and other aquatic organisms differ by species and also by the type of river channel, as well as the timing of the flows (Brown 1991). Specific flow needs vary depending on several factors including, but not limited to, the season (e.g. spawning and growth of fry), maintenance of flow for macro invertebrates, control of sedimentation for spawning areas and macro invertebrate habitat, dissolved oxygen requirements, eutrophication control, toxins that fish are sensitive to such as metals and ammonia, pH, water temperature requirements and other factors (Fleming, personal communication, June 2006).

In spite of the variations, several authors (Stalnaker 1980; Wesche and Rechard 1980 cited in Brown 1991) have suggested rules of thumb for estimating the needs for fish populations. Tennant (1976) concluded, that based on the observations from many rivers "good" fish habitat if winter (October through March) flows were never below 20% of mean annual flows and summer (April to September) flows would not fall below 40% of mean annual flow. Additionally, fish habitat would be excellent if at least 30% and 50% of mean annual flow were maintained during these two seasons. It would be considered outstanding if 40% and 60% of mean annual flow were maintained, and optimum if from 60% to 100% of mean annual flow were maintained (Brown 1991). On the Gila River this would mean the annual average flows would need to be between 75 – 125 cfs to be considered excellent, 100 – 150 cfs to be considered outstanding and 150 – 250 cfs to be considered optimum. An inconsistency with the rule of thumb is that criteria for excellent and outstanding are overlapping. Flows that fall into these categories could be classified at excellent or outstanding.

Table 6. Water Supply & Demand Impact on Fish Habitat

Historical Flows			Projected Future Monthly Averages (depletions have been subtracted)	AF converted to CFS	Projected Quality of Fish Habitat	
CFS	**Month**	**Percentage**	**AF**	**CFS**	**Winter**	**Summer**
386	January	13%	12,578	209.6	good	
367	February	12%	11,959	199.3	good	
460	March	15%	14,990	249.8	good	
301	April	10%	18,000	163.5		good
180	May	6%	5,866	97.8		good
59	June	2%	1,923	32.0		poor
80	July	3%	2,607	43.4		poor
248	August	8%	8,082	134.7		good
238	September	9%	7,756	129.3		good
156	October	5%	5,084	84.7	marginally good	
189	November	6%	6,159	102.6	good	
327	December	11%	10,656	177.6	good	
2,991	yearly total	100%	97,467			

4. Significance of Data

Assuming that the projected future uses of water are accurate, even in a high growth rate scenario with increased demand for surface water diversions, these data demonstrate that the future demand for water can be met with existing water supplies. A large water development project or dam is not necessary given the projected levels of growth. The water needs associated with future growth can be met with the existing supplies and will provide “good” fish habitat (according to Tenant’s 1976 the rule of thumb) for the majority of the year, with the exceptions being in June and July, due to low flow conditions. Given that the future depletions still provide “good” habitat, the impact of instream flows could be significant enough to improve habitat to "outstanding" conditions. In many instances, a small quantity of water dedicated to instream flows has a significant impact.

The importance of these data is that the existing supplies will meet the projected future demand. This provides the state with the opportunity to re-organize priorities for community and regional planning, placing environmental needs first and economic development, specifically growth and development, second. Recognizing the sustainable limits of the natural resources in this area is critical. Certain levels of growth are acceptable and sustainable, but because the state acquired new water rights on the Gila River does not mean that the region can now support unlimited growth. Without thoughtful planning, the natural resources that make the Gila Region unique, will be lost as new construction paves over the last wild river to build a foundation for the next housing development, strip mall or fast food restaurant.

B. Using the Private Market to Invest in Instream Flows: Option 1

In Option 1, the private market will be used to appropriate water rights to instream flows. This option provides the least amount of government control and involvement, as well as the least amount of protection for instream flows. Public and private organizations and / or individuals will determine how successful the protection of instream flows will become in New Mexico. This option provides the most flexibility for using the AWSA water rights, but the least amount of security that the water rights will be used as instream flows. While this option is experimental, there are many instances the private market effectively dedicating water rights to instream flows in other western states.

1. Rivers are Experiencing a Renaissance

In many communities throughout the country over the past decade or more, rivers have begun to enjoy a renaissance. Rivers that have been abused, paved over, and despoiled by runoff and refuse are taking a new significance as people recognize the

ecological importance of rivers and take pride in and work to reclaim waterways in their backyards (Grossman 2002).

Both individuals and organizations to protect the integrity of rivers' ecosystems value and appreciate nature, and therefore have a vested interest in working to restore the environment and protect rivers. Environmentalists and economists are recognizing that the private market can provide opportunities for environmental protection. Many economists state that market transfers of water provide a means to restore, improve, and protect environmental quality. In attempting to comply with the Federal Clean Water Act, western states are identifying surface waters that do not meet water quality standards. The primary reason many streams are not meeting water quality standards is inadequate flows, and low flows are challenging the recovery efforts for endangered fish species (Landry 1998). In the Rio Grande river basin, the silvery minnow exemplifies how species are struggling due to low flows. Recognizing that free flowing water plays a vital and integral role in water protection, the western United States is giving attention to increasing stream flows to improve water quality, and protect fish and wildlife habitat (Landry 1998).

2. Private and Public Groups Have Been Successful in Purchasing Water Rights for Instream Flows

Buying and leasing water rights for environmental protection is becoming an increasingly important method for protecting river and stream flows in the western United States. A limited number of studies have attempted to quantify information on the emerging water market for environmental protection. One of the first studies concluded that the market was very limited due to institutional constraints and transaction costs. Brown (1991) identified 15 acquisitions of market transfer rights in the western US from

1987 through 1991. Lease prices ranged from $2/ acre-foot to $7/ acre-foot and purchase prices varied from $9/ acre-foot to $14/ acre-foot. Most of the acquisitions were from irrigators and were used to augment low flows. Since these studies were conducted, many legislative and policy changes have occurred to support and encourage market transfers (Landry 1998).

Prices for water fluctuate considerably depending on demand and supply and the length of the right. Between 1990 and 1997, the average purchase price for instream water rights was approximately $400/ acre-foot. In the Rocky Mountain Region the average purchase price was $553 / acre-foot. However this average is derived from a small number of purchases that all took place in Colorado. The average purchase price in the southwest region was $420 / acre-foot. This region had 48 purchases, more than any other region, between 1990 and 1997. The Pacific Northwest had the lowest average purchase price as $153 / acre-foot (Landry 1998). The highest purchase price, $850/ acre-foot was paid by the New Mexico Interstate Stream Commission in 1994 for water rights needed to meet the Pecos River Compact (New Mexico Interstate Stream Commission 1998).

Much of the recent activity in instream flow markets is driven by actions to improve water quality and to restore flows for endangered fish species. Between 1990 and 1997, water sales for instream flows and environmental uses were reported in 9 out of eleven states (the exceptions being Wyoming and Utah). An estimated $61 million has been spent on leases and purchases of water for instream flow use over this period. Spending increased significantly in 1992, when total expenditures rose to more than $6.9 million, about four times the amount spent the previous year, on leases and purchases. The increase in spending reflects the initiation of several federal and state acquisition

programs, most notably the San Joaquin Refuge Water Acquisition Program funded by the Central Valley Project Improvement Act and the New Mexico Interstate Stream Commission acquisition program prompted by the Pecos River Compact (Landry, 1998).

The increasing number of transfers of water to protect water quality and fish and wildlife habitat in western U.S. is further exemplified with the following spending trends. From 1990 to 1997 more than $37 million was spent to lease 2 million acre-feet of water and $23.8 million dollars was spent to purchase 132,000 acre-feet for environmental protection. State and federal agencies are responsible for most of these market transfers. However, there is increasing activity by private organizations to acquire water for instream needs. There is a growing entrepreneurial effort by private organizations to acquire water for instream use (Landry, 1998).

In most western states, requests for ownership of instream water rights are limited to public agencies, most often water management, wildlife management, and pollution control or recreation agencies. In Alaska, Arizona, California, Nevada and New Mexico, private parties can hold instream flow rights. In both California and New Mexico, existing consumptive rights can be transferred or dedicated to instream uses, but the law does not authorize new instream appropriations (Nueman 2000). However, there have been cases where new instream appropriations have been made (Fort, personal communication, March 2006).

a. Overview of Federal Agency Acquisitions

During the period from 1990 to 1997, the federal government accounted for over half of the total market expenditures and was responsible for 70% of the total quantity acquired. The Bureau of Reclamation has been the lead agency to acquire water and has

started acquisition programs in Idaho, California, Oregon and Washington (Landry 1998). The US Fish and Wildlife Service (USFWS) is also active in buying and leasing water in California, Colorado, and Nevada (Landry 1998).

b. Overview of State Agency Acquisitions

There have been several changes in state water policies to create instream flow markets (Landry 1998). Over the years, states have recognized the social, economic, and environmental significance of free flowing water. During the 1960s and 1970s, the pressure to consider the value of free flowing water and establish instream flow rights dramatically increased. In addressing environmental needs, states initially relied on public action by reserving water from appropriation, establishing minimum stream flows, and placing use restrictions on new water rights, or by issuing new water rights for instream use (Landry 1998). However, the protection measures were implemented after the majority of the available water was appropriated to out-of-stream uses. Increasingly, states are considering market transfers as a viable option for protecting instream flows (Landry 1998).

States are commonly criticized for not allocating money to implement water acquisition programs. However, states are now increasing efforts to acquire water for instream needs. Between 1990 and 1997 state agencies throughout the western United States, have spent $10 million to lease 385,000 acre-feet of water and $15 million to purchase 65,000 acre-feet. Montana, Nevada and New Mexico have some of the most active state acquisition programs (Landry 1998). The New Mexico Interstate Stream Commission, one of the best state funded programs in the western United States, has spent more than $18 million to lease and purchase just over 276,000 acre-feet of water to

maintain flows and improve water quality in the Pecos River (NMISC 1998 cited in Landry 1998). A driving reason for water leases and purchases was to deliver Texas water owed under the Pecos Compact.

c. Overview of Private Sector Acquisitions

While state and federal agencies are spending their efforts and money to increase instream flows on large rivers, most private organizations are focusing restoration efforts on tributary streams, where small amounts of water can have a significant impact. For example, the Oregon Water Trust acquisitions are generally for less than 500-acre-feet; this is often equivalent to the entire flow of the stream (Landry 1998). For instance, the Oregon Trust spends $6,000 per year on hay on Buck Hollow, a small stream in central Oregon. In exchange for the hay, the water rights holder agrees to maintain the flow at one cubic foot per second. State fisheries biologists estimate that the stealhead population can increase from 30 spawning pairs in 1994 to as many as 500 spawning pairs with instream flow assurance. This purchase of instream flows exemplifies how private organizations with small budgets can profoundly contribute to improving ecosystems (Landry 1998).

Discussions in state legislatures and debates around water transfers for environmental protection are far more pro-market today than 20 years ago (Landry 1998). Changing attitudes and values have opened the market for increasing the number of instream flow market transactions. While there is potential for growth, until several western states ease the restrictions on private acquisitions of water rights for instream flows, markets may only see moderate growth. Montana, Oregon, Washington and Nevada have all adopted changes that allow private organizations to participate in the

market place. As a result, the markets in these areas are flourishing. Private organizations play an important role in providing opportunities for market transfers for environmental protection. These successful transactions demonstrate how private resources can and will be devoted to environmental benefits, such as instream flows and that the value of the resource is high enough to compete in the marketplace (Landry 1998).

Private environmental organizations are becoming active in water markets as converting water rights to instream flows becomes more popular. Since 1990, private groups have spent over $3.1 million to lease and purchase 22,000 and 9,000 acre-feet respectively. Private organizations are providing effective stream flows with limited budgets (Landry 1998).

3. Case Studies: Successful Instream Flows Programs

California, Idaho, Montana, Oregon, and Washington, have encouraged market transfers for environmental protection by allowing public agencies and private individuals to acquire water rights for instream flows. In 1987, Oregon adopted changes that allow public and private entities to lease or purchase water rights and convert them to instream flow rights (Landry 1998).

The Oregon Water Trust, a private organization established in 1993, uses a market-based approach to help maintain and restore surface water flows in rivers and streams throughout the state. The trust works cooperatively with willing water users to acquire part, or all of out-of-stream water rights. The group also work closely with local watershed councils, community leaders, governmental agencies and a range of public interest groups to prioritize and implement its efforts. Grants and donations fund the trust, which is governed by a nine-member board of directors that reflects the diversity of water interests in Oregon (Landry 1998).

The Great Basin Land and Water Trust, a private organization established in 1996, is helping implement the Truckee River Water Quality Settlement Agreement by purchasing $24 million of water rights in behalf of the cities of Reno-Sparks, Washoe County, the Pyramid Lake Pauite Tribe, and the US Department of the Interior. The water rights will be dedicated to instream flows to improver water quality during the summer months on the Truckee River. In addition the Great Basin Land and Water Trust is purchasing water rights for the state of Nevada for the benefit of the Carson Lake wetlands in Fallon, Nevada (Landry 1998).

The Washington Water Trust, a private organization established in 1998, is restoring flows in Washington's rivers and streams by acquiring existing rights and transferring them to instream rights. The focus is on market-based approaches to improve water quality, fisheries, recreation, and other public values related to insteam flows (Landry 1998).

More traditional environmental organizations are changing and expanding their roles. The Environmental Defense Fund (EDF), The Nature Conservancy (TNC), and Trout Unlimited (TU) have participated in water acquisitions in Idaho, Colorado, Nevada, Oregon, and Montana (Landry 1998).

The EDF played an instrumental role in organizing the first water right transfers in Washington. In 1994, the EDF report *Restoring the Yakima River's Environment,* recommended using voluntary transfers of water rights to help restore the aquatic habitats in both the Yakima and its tributaries such as the Teanaway. This report was the foundation for the Bureau of Reclamation's pilot acquisition program in the Yakima (Landry 1998).

Recently, donations have become an important method or acquiring water for instream flows by private organizations. Private groups negotiated 50 of the 60 donations that occurred between 1990 and 1997. The Oregon Water Trust has been especially successful with 46 of the 50 donations. Most donations were for small quantities of water ranging from 15 to 1000 acre-feet (Landry 1998).

Montana Trout Unlimited successfully negotiated the first private lease of an irrigation water right to be converted to an instream flow in the state. The ten year lease agreement provides an additional 460 acre-feet of water in Rock Creek, a small stream in western Montana. The Nature Conservancy of Montana was one of the first private organizations to become involved in water leasing in Montana. In 1991, the conservancy helped raise money to create the Montana Water Leasing Trust Fund. At the time that the trust was created, the state Department of Fish, Wildlife, and Parks was the only entity allowed to lease water rights for instream flows. The trust served as a repository for contributions from private individuals, foundations, and corporations who are interested and want to help implement the leasing program (Landry 1998).

The Oregon Water Trust, the Washington Water Trust, and Nevada's Great Basin Land and Water Trust are three new groups using market techniques to acquire senior water rights and convert them to instream flows (Landry 1998). New Mexico can look to these organizations as role models for providing alternatives for acquiring water rights for instream flows.

4. Government Involvement

This approach requires the least amount of government control and involvement. Transactions in the private market would determine the successful instream flows. The interests of parties involved in the water market would guide water appropriations. For

example, a farmer could lease his/ her water rights to a party who would use the water rights for instream flows. This relationship could create political good will. However, increasing the marketability of free flowing water creates the danger that environmentalists (or other groups) could argue that anyone could lease water from farmers, including developers and other interests who wish to use the water for an out-of-stream uses. If a developer, or other interest, claims they are being discriminated against, their argument could be dismissed due the public trust doctrine, which protects water for the public. I discuss supporting arguments that maintain that instream leases are permissible, while other leases are not due to the public trust doctrine in option 3.

5. Costs Are Privatized

The cost of using water rights as instream flows is privatized, which means there is no cost to the state, but there is no economic gain for the state either. The state has the opportunity to save money by avoiding the costs of recovery plans for species that are listed as endangered or threatened due to low flows, and the administrative costs are privatized. The consequence of letting the private market control the use of instream flows is that people may not wish to buy or lease water rights for instream flows, and the state has no ability to change peoples' spending habits.

6. Opposition

It is difficult to say how the public would react to Option 1, but it is likely that there would be considerable support because it would not require the public to change its behavior, but would allow the public the opportunity to engage in the private market if they desired. However, if no one purchased or leased water for instream flows and the water rights were used for out-of-stream needs, the river could change drastically.

The private water market allows individuals and groups to purchase water rights for instream flows, which could lead to more community support or involvement, which in turn could create more civic action and investment in management of local natural resources. The ability to buy water rights in a local stream means a new sense of environmental stewardship may emerge.

C. New Mexico Leases Water Rights To Arizona: Option 2

In Option 2, New Mexico would lease the AWSA water rights to Arizona. Arizona would most likely find this option very appealing due to their high growth rate and increased demand for water. The water rights would be appropriated as instream flows in New Mexico, which would provide significant environmental benefits for the state of New Mexico. However, the water would no longer be protected from diversion after crossing the Arizona state line, which could result in considerable environmental degradation in Arizona. In an ideal situation, New Mexico and Arizona would collaboratively develop an insteam flow program to maintain ecological integrity along the Gila River throughout the entire basin.

1. Arizona's Demand for Water is Increasing Rapidly

The state of Arizona, as well as some of its counties and cities, are some of the fastest growing regions in the country. Arizona's population in 1990 was 3,665,228, in 2000 it was 4,961,950, and in 2020 it is projected to be 7,444,625, representing a 103.1 percent increase from 1990 (Ensuring Arizona's Water Quantity and Quality into the 21st century, Arizona Town Hall, 1997). In the town of Gila, Arizona the population density has changed from 5.1 in 1950 to 9.3 in 1995, and in Yuma, Arizona, at the Gila River and Colorado River confluence, the population density has changed from 2.8 in 1950 to 22.3 in 1995 (Arizona's Growth and the Environment, Arizona Town Hall, 1996). Given the

high rate of growth in Arizona, the state will need to determine how it will meet its increasing water needs, and may be interested in leasing water from New Mexico.

2. Lease to Arizona will Guarantee that New Mexico will Meet its Downstream Delivery Obligations

Not only do interstate water leasing agreements need to determine how to meet water demands, but they also need to consider emerging social values, particularly those focused on environmental protection and holistic watershed management. In most cases, traditional western interstate compacts provide no protection for instream flows (Booker 1999). However, leasing water to downstream user serves as a method to keep water in rivers due to downstream delivery obligations. In addition to creating a leasing agreement, this option would also appropriate the water rights as instream flows in New Mexico to ensure the delivery, providing multiple benefits simultaneously.

Instream flow protection can aid the state in fulfilling downstream delivery requirements established in a leasing agreement on an interstate river, as well as protect the environment, particularly endangered species. Establishing instream flows ensures that water that will not be diverted from the river, which means Arizona would have more incentive to enter a lease agreement knowing a mechanism that supports downstream delivery is in place. Also it would guarantee that water remains in the riverbed in the headwaters, which are critical to the health of the entire river system (Grossman 2002). Instream flows support the ecosystem by increasing riparian vegetation, which provides toxin filtration and leads to improved water quality, supporting all endangered species by improving aquatic habitat (for fish spawning), as well as riparian and terrestrial habitat (particularly for birds), the ability to transport genetic information (such as seedlings), and other environmental benefits (Fleming, personal communication, June 2006).

Another legal consideration is the Consumptive Use Forbearance Act (CUFA), which is one of dozens of agreements between parties that congress ratified in the four titles of the Arizona Water Settlements Act. The CUFA details New Mexico's contractual right to develop and consumptively use on average up to 14,000 acre-feet of water from the Gila Basin (NMISC 2006). One of the three major provisions of the CUFA is that the intent of the CUFA is to allow the Secretary to exercise the rights authorized in the 1968 Colorado River Basin Project Act and to prohibit the Arizona parties from challenging New Mexico water uses that are in compliance with the CUFA (NMISC 2006). This provides Arizona with more of an incentive to enter a leasing agreement with New Mexico because Arizona cannot challenge CUFA in court to obtain more water as demands increase.

CUFA requires that the NMISC and Bureau of Reclamation (BOR) conduct National Environmental Policy Act (NEPA) assessments to integrate environmental values into their decision-making processes by considering the potential environmental impacts of proposed actions and reasonable alternatives to those actions. Additionally, an Environmental Impact Statement (EIS) will be written (NMISC 2006). Using instream flows to lease water to Arizona will benefit the environment, making this option compatible with NEPA. The impacts of Option 2 are benevolent to the environment, again meaning that the EIS will most likely support it.

Both the upstream and downstream water users would benefit from a leasing agreement. The instream flows would support the local riparian habitat in the upper watershed in New Mexico, as well as the riparian habitat in Arizona's riparian corridor until it was diverted. This option would create a method for simultaneously increasing and protecting instream flows and increasing economic gains.

The effect of New Mexico's leasing water to Arizona would be similar to the presence of downstream senior water rights holders along the Rio Grande. Downstream water right holders have inadvertently helped augment instream flows for the Rio Grande silvery minnow, which is listed as an Endangered Species. The habitat of the Rio Grande silvery minnow has been partly helped by these downstream deliveries (Booker, 1999). Much like the Rio Grande Compact and Treaty, the AWSA bypass deliveries to Arizona are minimal, and do provide a base flow at certain times of the year. The Gila River, like the Rio Grande, experiences seasonal fluctuations of dewatering. These circumstances provide reason to appropriate the water for instream uses, giving them a greater level of protection to ensure downstream delivery. Also, the Gila River supports a habitat that is home to several endangered species including the Gila chub, spike dace, loach minnow, willow flycatcher and as well as other species (USFW 2006).

3. Leasing Water Rights to Arizona will Generate Revenue for New Mexico

The market for annual leases is growing. The average lease price between 1990 and 1997 was $30/ acre-foot annually. The Southwest region of the U.S. exhibited the highest average lease price with a price of $35/ acre-foot. The average lease price in the Pacific Northwest was $30/ acre-foot and they experienced the highest number of leases with 92 occurring between 1990 and 1997. The lowest lease price was $0.08 / acre-foot paid by the New Mexico Interstate Stream Commission to Mississippi Potash incorporated. The reason they entered this agreement was to avoid losing their water right due to a lack of use. The lease ensured that the water was being put to beneficial use (Landry 1998). The price of water during a low water year will increase, making it more attractive to use water leasing (Green 2001).

A lease will require more government control and involvement than Option 1. In Option 2, the state would lease the AWSA allocation of water to Arizona, which would include a moderate amount of government control. The private market would determine the price of the water leased. The state would reap the financial benefits from the leasing agreement. The costs of this option are to the state that would have to pay for litigation costs to create the leasing agreement, the costs of non-delivery if circumstances prevented New Mexico from delivering the water, and the administration of acquiring the water rights. The costs saved from this option include the cost of a recovery plan for endangered and threatened species due to low flows.

4. Opposition

Public support for Option 2 would probably be moderate. The state would be leasing water rights out of state that private instate interests could obtain otherwise. The state would benefit financially, which means the public could benefit from the leasing agreement if those funds were used locally for a public project. The public would enjoy the benefit of the Gila River being protected through the use of instream flows and remaining unchanged.

D. New Mexico Dedicates its New Water Rights to Instream Flows on the Gila River: Option 3

In Option 3, the state will withdraw a certain quantity of water rights from appropriation so that instream flows are preserved from depletion by private appropriators. New Mexico would dedicate the new water rights to instream flows and not allow any of these rights to be bought, sold or leased. Both the Endangered Species Act and the Public Trust Doctrine support the use of instream flows in the Gila River. While the use of both of these legal doctrines would mean more government control, the

protections they offer to the public would be greater than allowing the water rights to be controlled by the private market.

1. The Endangered Species Act Supports the AWSA Dedication to Instream Flows

In 1973, Congress passed the Endangered Species Act, which recognizes that our natural heritage is comprised of "esthetic, ecological, educational, recreational, and scientific value to our nation and its people" (USFW 2006). The Endangered Species Act (ESA also referred to as the Act) is a federal statute designed to protect plant and animal resources from adverse effects due to development projects. It provides for the designation and protection of invertebrates, wildlife, fish and plant species that are in danger of becoming extinct and conserves the ecosystems on which these species depend (DOE 2006).

"The Act defines an endangered species as any species that is in danger of becoming extinct throughout all or a significant portion of its range. A threatened species is one that is likely to become endangered in the foreseeable future. The Act makes it illegal for any individual to kill, collect, remove, harass, import or export an endangered or threatened species without a permit from the Secretary of the Department of the Interior " (DOE 2006).

The Interior Department's U.S. Fish and Wildlife Service and the Commerce Department's National Marine Fisheries Service (NMFS) administer the ESA (USFWS 2006). The Secretary of the Interior lists species that are endangered or threatened. Whenever possible, a designation of the critical habitat accompanies the listing. The Secretary of the Interior also must publish and periodically update the lists and develop and implement "recovery" plans for the conservation and survival of the endangered and

threatened species. The Act also directs the Secretaries of Interior and Commerce to establish programs to conserve fish, wildlife, and plants (DOE 2006).

Recovery, meaning that the species no longer need protection under the ESA, is the ultimate goal of the law. Recovery plans explain the steps needed to restore a species to ecological health, and the associated costs. Appropriate public and private agencies assist in developing and implementing recovery plans. Involving public and interested stakeholder participation is promoted (USFWS 2006). In order to recover an endangered species, habitat must be restored to meet the needs of the listed species. Critical habitat for different threatened or endangered species could be restored or improved with increased instream flows.

The upper Gila River basin has several species listed under the Endangered Species Act including the spikedace and loach minnows, Gila chub, Chiricahua leopard frog, the Western (or Apache) frog and the southwestern willow fly catcher (NMISC 2003). According to Marilyn Meyers, Senior Fish and Wildlife Biologist at the USFWS in Albuquerque, the listed species most likely to be affected by water withdrawals on the Gila River are the federally listed loach minnow (threatened), spikedace minnow (threatened), southwestern willow fly catcher (endangered), chiricahua leopard frog (threatened), Chihuahua chub (proposed endangered), yellow billed cuckoo (candidate) and possibly the bald eagle, depending on the project (Meyers, personal communication, September 2006).

According to Siwik (2004), the executive director of the Gila Conservation Coalition, scientists are assessing whether or not the existing native fish species in the Gila Basin will be sustainable in the long term. One study, published in 2004, stated that only 40% of the historic native species are now found in the Gila Basin, about 70% of all

native fish in the Gila Basin are listed as threatened or endangered, and many others are candidates for listing (Siwik 2004). This contradicts what Rice and McNamee reported, which most likely means that the number of native fish species in the Gila River is uncertain.

Given the latter statistics, the habitat conditions are not suitable for the majority of fish species in the Gila River. Dedicating the new water rights to instream flows will not only allow the current condition that minimally sustains the species to persist, but improve conditions. If the water is diverted, the fish species will be at greater disadvantage and the population will most likely be adversely affected. The headwaters of the Gila River in the Gila Cliff Valley are critical to the survival of native fish in the Gila Basin as this reach of the river still provides adequate habitat for native fish to dominate (Siwik 2004)

a. Stream Flows Needed to Maintain Species and Habitat

Rivers and stream corridors provide various valuable natural resources including aquatic habitat for fish and other aquatic life as well as riparian habitat for terrestrial wildlife. Rivers and streams following natural channels create ribbons of habitat throughout the arid west that is critical for life cycles of various species, as well as to the general ecosystem (Shupe 89). Streamflows are needed to sustain a healthy ecosystem and are critical for the survival of diverse aquatic and riparian habitat, particularly for endangered species habitat, mainly for fish. The failure to balance environmental protection with water use has led to the extinction and threat of extinction of several aquatic and riparian species (Fort 2000).

An important function of adequate instream flows is to maintain the physical capacity of streambeds and channels to carry run-off. Instream flows transport sediment that would otherwise clog the channel and create various problems. Sediment buildup can result in flooding, erosions, meandering of the streambed, a reduction of the overall capacity to carry runoff (Shupe 1989). Channel maintenance requires base flows, plus occasional flows at much higher volumes (Brown 1991). High flows are needed to overflow channels and floodplain environments to recharge groundwater resources (Siwik 2004). On the Gila River, flows are highly varied from year to year, but typically are characterized by long durations of low flows followed by short-duration, high volume flows (DB Stephens 2005).

Flood scouring prepares the substrate for cottonwood and willow germination. According to Siwik (2004), research on similar southwestern rivers has shown that as flows become increasingly intermittent and groundwater retracts or deepens, conditions become increasingly less ideal for cottonwoods and willows and more suitable for tamarisks. A ten foot drop in the water table is detrimental to cottonwood survival, which could lead to the loss of riparian forests which support a large variety of wildlife, some of which are threatened or endangered (Siwik 2004).

b. How Much Water is Needed?

How much water is needed to support various aquatic and terrestrial species is the million-dollar question. Living organisms evolve as conditions change and conditions continually change. If the answer were clear, managing water resources would be much more straightforward. Because nature is not easily defined or predictable, many people are working to determine the best methods for answering this question. Presently a group

comprised of experts in various fields, is in the process of developing a dynamic systems model to show the relationship between stream flows and habitat for various aquatic and terrestrial species as part of the planning process to determine how to use the AWSA water rights (Meyers, personal communication, September 2006). While the benefit of dynamic systems models is they represent changing relationships, the drawback of these models is that they are complex, take time and money to develop and don't provide definitive answers. The issue of how much water is needed pertains to all three options discussed in this paper, as well as the multiple other options that are being considered as the state engages in this decision making process.

c. Prevention vs. Mitigation

A comparison of the total cost of recovering each listed species to the total cost of implementing instream flows demonstrates that it is far less expensive to prevent a species from becoming listed as endangered or threatened than to mitigate after a species is listed. To exemplify this, the recovery plans of the following endangered species listed in tables seven and eight estimate the cost of recovery. While the cost of implementing instream flows is less clearly defined, it would be significantly less costly.

Table 7. Southwestern Willow Flycatcher Recovery Costs in Thousands of Dollars
(Southwestern Willow Flycatcher Recovery Team Technical Subgroup, 2002)

Year	Total Cost in Dollars
FY 01	13,261
FY 02	13,216
FY 03	17,233
FY 04	16,228
FY 05	16,383
FY 06	34,590
FY 21- 30	16,510
Total Cost	127,466

*does not represent total potential funds due to inability to estimate costs for specific recovery actions at this time

Table 8. Cost to Recover Chiricahua Leopard Frog in Thousands of Dollars
(Draft Recovery Plan, April 2006, US Fish and Wildlife Service)

Year	Minimum Cost in Dollars
2005	710
2006	739
2007	763
2008	637
2009	564
2010	to be determined
Total Cost	3,413

<u>Spikedace</u>

The cost of recovery over a minimum period of twenty years equals a total minimum cost of $115,000. This cost is in 1989 dollars and does not include land or water acquisition (US Fish and Wildlife Service, 1991)

<u>Loach Minnow</u>

The total estimated cost of recovery for the loach minnow over a minimum twenty years is minimally $115,000. This estimate is in 1989 dollars and does not include water or land acquisition (US Fish and Wildlife Service 1991).

d. Methods for Putting Water in a Stream Bed for Listed Endangered and Threatened Species

In situations where endangered species are identified and critical habitat established, flow requirements may be imposed through a notice in the Federal Register rather than through state permits (Fort 2000). Federal purchase or lease of water rights under state law for species protection may come to be seen as a more orderly way of providing water for instream purposes. Under the pressure of the Endangered Species Act (ESA), the New Mexico Office of the State Engineer (OSE) has urged this course of action on the Department of the Interior. Throughout the West, the federal government has provided financing for river restoration and species protection (Fort 2000).

Dedicating water rights to instream flows guarantees that the quantity of water stated in the water right will not be diverted from the stream channel. These water rights are protected like other water rights, meaning the increased volume will help improve habitat conditions for endangered and threatened species.

e. River Rehabilitation has Achieved ESA Goals on the Gila River

The US Fish and Wildlife Service decided to reclassify the federally listed endangered Gila Trout (Oncorhynchus gilae) to threatened status under the authority of the Endangered Species Act of 1973. A special rule under section 4 (d) is also being applied to Gila Trout in New Mexico and Arizona. This special rule will enable the New Mexico Department of Game and Fish and the Arizona Department of Game and Fish to officially announce that recreational fishing of Gila trout is now allowed (USFWS 2006).

The Gila Trout Recovery Plan stated that the Gila Trout could be down listed "when survival of the four original ancestral populations is secured and when all morphotypes are successfully replicated or their status appreciably approved" (USFWS

2006). From 1979 when the Recovery Plan was first implemented, there were several instances when the US Fish and Wildlife Service considered delisting the Gila trout but weren't able to. Finally it became effective August 17, 2006 (USFWS 2006).

Today all four pure populations of Gila Trout including Main Diamond, South Diamond, Spruce and Whiskey Creek are replicated at least once. Surveys of the 12 existing populations indicate that the recovery efforts to remove non-native fish and prevent their return to the renovated areas were successful. There has been an increase in the total wild population of the Gila Trout overall (USFWS 2006).

Using instream flows will help prevent additional species from becoming listed as threatened and endangered. The existing level of water and habitat conditions on the Gila River contributed to the increase in population of wild Gila Trout. If New Mexico were to dedicate the new water rights to instream flows, the successful step towards the recovery of the Gila Trout could be just the beginning of the recovery of many listed species. The Gila Trout is now listed as threatened. While this is can be considered an improvement, many more improvements must take place before it is consider a complete recovery or victory.

The change of status of the Gila Trout from "endangered" to "threatened" will provide an immediate economic opportunity in sport fishing. The fishing industry will probably increase as many people are interested in Gila trout and have not had the opportunity to fish for Gila Trout in decades.

f. The Dedication of Water to Instream Flows in Colorado has Achieved ESA Goals

One example of how the Endangered Species Act can support maintenance of instream flows is demonstrated in western Colorado. The humpback chub, squawfish and

bonytail chub, all endangered fish species, live in the Colorado River. The U.S. Fish and Wildlife Service has developed plans for the preservation and recovery of the species in the Upper Colorado River basin, which included purchasing existing water rights to increase stream flows. Any new water diversion in the area will have to conform to instream flow mitigation measures mandated by the final recovery plan (Shupe 1989).

In the South Platte River basin in eastern Colorado irrigators wanted to build a reservoir on a tributary of the South Platte, but were denied their request for a permit from the U.S. Army Corps of Engineers due to the potential effect on endangered species habitat. While the reservoir itself didn't contain any endangered species, the capture of spring runoff that would normally flow downstream to the mainstem of the Platte River was seen as a potential threat to the whooping crane habitat in Nebraska. Whooping cranes are dependent on high flows to keep safe from their predators during their journey through this region (Shupe 89).

2. Public Trust Doctrine Supports the Dedication of AWSA Water to Instream Flows

Another legal policy that supports instream flows is the public trust doctrine, a common law doctrine with ancient roots in English and Roman law (Nueman, 2000). "The sovereign could not prevent people from using tidelands and coastal waters for fishing and navigation needed for public good" (Shupe 1989). This principal continued into American jurisprudence, and constrained state governments from selling coastal lands to private enterprises, to the detriment of the public needs in these areas (Shupe 1989). This doctrine requires the state, in managing its water resources, "to protect public rights to use water bodies for commerce, navigation and fisheries – and possibly recreation and aesthetics as well" (Nueman 2000).

In 1983, the California Supreme Court ruled that Los Angeles' diversions from tributaries of Mono Lake were subordinate to the public values supported by the lake. The lowered levels of the lake were destroying public values such as bird habitat and scenic beauty, and the court ruled that the diversions had to be curtailed. According to the public trust doctrine, California, as a sovereign had no right to issue permits for water diversions that would undermine public values. The Mono Lake decision was monumental in that it presented an opportunity to reallocate water resources from historical uses to instream flows in the west. However, states other than California and Idaho have not ruled on whether the public trust doctrine applies to the protection of local inland waters (Shupe 1989).

Conflicts arise from the public trust doctrine. Parties in favor of the public trust doctrine view it as a vehicle to re-establish a public interest in fully appropriated streams without costly expenditures. Those opposing the public trust doctrine perceive it as an "underhanded means of side-stepping constitutional protections and taking vested property rights of farmers and other senior water users" (Shupe 1989). If private parties challenge the state's implementation of Option 3, the state could argue that the public trust doctrine supports Option 3. The waters of New Mexico are public and the state has the responsibility to protect the waters for the public under the public trust doctrine.

The level of government control associated with the public trust doctrine "carries the biggest threat to the consumptive water interests, not only in terms of controlling instream flow programs, but also in retaining control over their water rights" (Shupe 89). The public trust doctrine raises a difficult question. Should the public trust doctrine be used to support free-flowing water and re-establish depleted streams at the expense of already established diversionary water rights, or should the public have to pay to

supplement important instream flows? In order to find solutions to these complex questions, which have implications on cultures, economies and the natural ecosystem, cooperation amongst many people will be required (Shupe 1989).

3. Opposition

The public support for option 3 is probably the most difficult to predict because this option is likely to create more controversy than the other options. There could be a vast division those in favor of support versus those opposed. The use of increased government control to establish instream flows provides the greatest level of protection of the Gila River, but also denies the public the opportunity to participate in the water rights market or use these water rights for out-of-stream purposes. The people of southwestern New Mexico are known for valuing independence from the federal government and the community members here may not support increased government control or involvement.

Option three would provide benefits that would enable the greatest number of people to enjoy the Gila River as a wild river. Based on the national trend, which demonstrates a significant increased interest in river protection during the past two decades, there may be considerable public support for option 3. If the actions of the Gila Conservation Coalition are representative of community members in this region, it seems that residents in the area have a vested interest in working to preserve the character of the Gila River, which is central to the sense of place in this region.

The disadvantage of public agencies owning instream rights is that the right to see that the appropriate amount of water remains instream may be compromised due to political ties. The prior appropriations doctrine is “complaint driven” (Stern 1997). Water rights are satisfied and enforced according to seniority. Water rights holders must take action or complain when they are not receiving their water, and then the water

management agency is supposed to respond to enforce the delivery of water according to priority (Neuman 2000). Another disadvantage of the complaint system is either a state paid agent or the owner of the right need to be constantly vigilant to protect the rights (Fort 2000). If the owner of an instream right is the water management agency, such as in Colorado and Oregon, the political pressure not to "complain" or enforce its own right can be significant. This is an especially sensitive issue if satisfying the instream right will come at the expense of the agency's other clients, namely consumptive rights holders, who will have to watch the water flow by and not be able to take it for themselves. Other groups can call for enforcement, but they are unlikely to have the same clout as a water right holder (Neuman 2000).

Furthermore, placing ownership with public agencies is putting instream rights more vulnerable to shifts in political winds over the long term than when ownership is private. Also, if political opposition to instream flows continues to increase, there may not be any provisions in place to prevent the reduction or elimination of instream rights (Neuman 2000).

CHAPTER 6: RECOMMENDATIONS

The goal of my research is to evaluate options for using the AWSA water rights as instream flows in New Mexico. My recommendations for dedicating the new water rights to instream flows will transform the way water is being managed in the state, actively improve ecological health and integrity, strengthen on-the-ground river restoration efforts and eliminate unnecessary barriers to protecting the rivers.

Using a combination of the three options provides the most flexibility, while accommodating the needs of broadest spectrum of stakeholders, ranging from the Gila River itself to commercial developers in Arizona. Using multiple methods provides a greater opportunity for success because if one method proves to be ineffective, the others still have the potential to be effective.

I recommend using the water rights from the AWSA for instream flows in the following way: dedicate 50% to Option 3 (dedicating the water rights to instream flows), 25% to Option 2 (leasing the water to Arizona) and 25% to Option 1 (using the private market).

While there is discussion in the water resources field about the need for water for growth and development, the need for water for the environment is a greater priority because our continued existence as human species depends on a healthy environment. Rivers have been paved over, dammed and dumped on for the progress of cities, suburbs, and highways. They have been used and abused in the name of growth and development throughout the West (Grossman 2002). The U.S. government (through the Army Corps and Bureau of Reclamation) has re-engineered rivers to the point that they require

constant maintenance. The threat of allowing rivers to naturally maintain themselves is often too great a threat to the communities and people living adjacent to them.

Water development projects have diminished floods, changed seasonal variations of flows, dewatered riverbeds for irrigation and other purposes and created other adverse effects, which have often led to the extinction or near extinction of several species. Ecosystems and rivers have been debilitated in their ability to maintain themselves due to water development projects that have altered their natural course.

The use of greater government control is necessary to create secure instream flows protection. Options 1 and 2 depend on transactions in the private market to determine the value of water for instream flows. The danger of the private market is if there are no willing sellers or buyers, instream flows protection could fail. Conversely, there is also a threat of too many players becoming involved in the market and driving the price of water too high to make Option 1 practical. However, case studies and research show that the market for buying and selling instream flows is increasing, and that instream flows have been successfully utilized via the private market in other states throughout the West.

An option 2, leasing the water to Arizona, provides an opportunity for the state to protect instream flows, earn financial benefits, and create political goodwill with a neighboring state. Since Arizona has historically used the Gila River to meet their water needs, and there is an increasing demand for water in the state due to the rapid rate of growth and development, they are likely to favorably consider a leasing agreement. However, the drawback of this option is the environmental benefits stop at the state

border. Significant and increased withdrawals from the Gila River in Arizona could result in dramatic environmental effects in this area of the Gila Basin.

Option 1, using the private market to allow private appropriators buy, sell and lease water rights for instream flows, is the most experimental. There is potential for this option to be highly successful, but it is uncertain. Those who know the water market or wish to protect the Gila River will be the most likely to engage in these transactions. This option gives people an opportunity to financially support their beliefs and could result in increased interest in environmental stewardship, as people recognize the role they could play in determining the fate of the Gila River.

In both options 1 and 2, if private parties or the state of Arizona do not wish to buy, sell or lease the water rights, then the state has the option of appropriating this water for another use. The benefit of these options is that if the water needs of the region do change, or the projections do not prove to be accurate, this water could become available to the state for other purposes.

A. Cost and Benefits of Options

I recommend these options because they are cost effective and provide important environmental benefits. The cost of implementing the three options is minimal, with the greatest cost being the preparation and negotiation of the leasing agreement with Arizona. The administration and monitoring costs would easily fall within the limits of the available funding.

All three of the options save costs associated with preparing and implementing recovery plans for federally listed endangered and threatened species due to inadequate

flows, administrative costs are eliminated when the transactions are privatized and the cost of non-delivery will be removed due to instream flow protection.

In Option 2, the state directly earns financial profits from leasing the water to Arizona. However, all three options provide indirect financial profits the state economy in the recreation and tourism industry. Also, an intact ecosystem provides air and water quality benefits as the riparian vegetation serves as a filter for both air and water. People are more likely to recreate in areas high air and water quality.

B. Spending Federal Funding: $66 million

These recommendations intend to use the federal funding in a way that achieves the greatest impact for every dollar spent. I recommend using the funding to implement and monitor my recommendations for using the water rights as instream flows using the specific combination of the three options discussed earlier. The total cost of implementing this project will be less than $66 million. I recommend using the remaining funding for scientific research.

The AWSA permits that the funding can support water development projects such as hydrologic studies or mitigation, restoration and/or environmental measures, and that the work does not have to relate to the state's Central Arizona Project (CAP) allocation (Arizona Water Resources 2004).[4] I interpret this to mean that the funding can be used to mitigate already existing damage or to improve environmental conditions, which is why I recommend using the funding to support scientific research.

[4] For more information on the Central Arizona Project (CAP), see the 2004 Arizona Water Resource Newsletter.

C. Scientific Research

I recommend using the funding to improve scientific monitoring and assessment throughout the entire upper watershed. The biological conditions of the watershed, including terrestrial and aquatic species, should be studied more regularly and in greater detail, particularly in the headwaters, which will impact water quality throughout the entire watershed. Frequent monitoring and assessment will provide detailed and accurate data, which are needed to make water resource planning decisions that will sustain the needs of both humans and natural environments.

There is a need for scientific studies to provide a greater understanding of the relationship between flow levels and habitat conditions. Studying the threshold of limits for various species survival will provide useful data for water management decisions regarding appropriation and diversions.

The state would also benefit from using some of the funding to improve monitoring of surface water diversions, particularly for irrigation because of the large quantities of water diverted and returned in this sector. Funding should also be used to enforce compliance when water users are not complying with the level of withdrawals and return flows stated in their water rights.

A portion of the funding should be used for implementing strategies to improve water quality conditions for any reaches of the Gila River that are not in compliance with state standards. Also funding should support on-the-ground restoration efforts, such as tree thinning and planting, removing of non-native riparian vegetation, installing instream structures that support induced meandering, building cattle exclosures and implementing other projects that will improve riparian health. While the initial restoration efforts will

be site specific and treat small tracts of land or reaches of river, the state would benefit from developing a broader plan for improved habitat along the entire Gila River in New Mexico.

CHAPTER 7: CONCLUSION

New Mexico is in the process of making a decision that will impact the environment, the economy and the people of the state. The Gila River is the last free flowing river in New Mexico and supports biodiversity that is unique and important to the southwest. Many of these aquatic and terrestrial species are at risk of becoming endangered or threatened and are federally protected. The use of instream flows to protect and improve habitat conditions is critical not only for the survival of the species, but also for the river itself.

Instream flows provide mutual benefits for both the ecosystem and economy. Dedicating AWSA water rights on the Gila River to instream flows recognizes the value of the natural landscape, as well the aquatic and terrestrial species it supports.
Years of government support for growth and development in the West, which was largely focused on changing the natural environment to suit human needs, has damaged ecosystems, particularly rivers. Time has demonstrated the detrimental effect of this type of development on river systems. Since the beginning to westward expansion, scientific knowledge has drastically improved. Presently, decision makers in the government, scientific fields, and communities, have too much information available to them to make a scientifically irresponsible decision. Prioritizing environmental protection, specifically for water resources in an arid climate, is necessary for sustainable and continued growth in New Mexico.

The Gila River is the lifeblood of this arid region and the backbone of the Gila Wilderness Area. The establishment of the Gila Wilderness Area signifies an historic event, as it was the first protected wilderness in the United States. Aldo Leopold, a

conservationist for the United States Forest Service, who lobbied to permanently protect this area, had a vision of this landscape remaining undeveloped so future generations could enjoy a wild place. This type of protection jump-started a movement to protect other areas of unique natural beauty. Americans and international visitors alike appreciate and regularly visit the natural landscapes that have been preserved in this country. For this reason, it is of utmost importance to protect the Gila River, and keep the state's last wild river wild, not only for ourselves, but also for future generations.

References

Arizona Water Resource Newsletter (May, June 2004). In Settling CAP Affairs AZ Confronts Project's New Mexico Unit. *Arizona Water Resource Newsletter, 12.*

Arizona Water Resource Newsletter. (July, August 2004). Arizona- New Mexico Agreement Clears Way for Action on Arizona Water Settlement Area. *Arizona Water Resource Newsletter*, *13.*

Arizona's Growth and the Environment, 1996: Arizona Policy Choices. (1998).

Brown, T., Daniel, T. (1991). Landscape Aesthetics of Riparian Environments: Relationship of Flow Quantity to Scenic Quality Along a Wild and Scenic River. *Water Resources Research,* Vol 27, No. 8, 1787 -1795.

Brown, T. (1991). Water for Wilderness Areas: Instream Flow Needs, Protection, and Economic Value. *Rivers, 2,* 311-325.

Brown, T., Taylor, J., & Shelby, B. (1992). Assessing the Direct Effects of Streamflow on Recreation: A Literature Review. *Water Resources Bulletin: American Water Resources Association,* 27, 979-989.

Brunner, R., Colburn, C., Cromley, C., Klein, R., &Olson, E. (2002). *Finding Common Ground: Governance and Natural Resources in the American West.*

Chermak, J. (April 2006). Lecture: Water Resources Modeling.

D.B. Stephens & Associates, Inc. (2005). Southwest New Mexico Regional Water Plan, Vol. 1, Report Text Appendix A, Prepared for the Southwest New Mexico Regional Water Planning and Steering Committee

Department of the Interior Fish and Wildlife Service. (2006). Endangered and Threatened Wildlife and Plants; Reclassification of the Gila Trout (Oncorhynchus gilae) From Endangered to Threatened; Special Rule for Gila Trout in New Mexico and Arizona. *Federal Register, 71,* 40657-40673.

Ensuring Arizona's Water Quantity and Quality into the 21st Century, Arizona Town Hall, 1997, Morrison Institute for Public Policy. Arizona Policy Choices. (1998).

Fleming, W. Personal communication. June 2006.

Fort, D. Personal communication. March 2005

Fort, Denise. 2000. Rivers, Volume 7, number 2. Instream Flows in New Mexico (155-161)

Getches, D. (2003). *Water Law.* St. Paul: WEST PUBLISHING CO.

Gila Conservation Coalition, Action Alert, www.gilaconservation.org, Accessed on April 10, 2006.

Gila Wilderness, http://www.nmwild.org/wilderness/gila accessed on April 10, 2006.

Green, Gareth P. (2001). *Water banking and restoration of endangered species habitat: An application to the Snake River.* Contemporary Economic Policy Huntington Beach: Vol. 19, Issue 2 p 225

Grossman, E. (2002). *Watershed: The Undamming of America.* New York: COUNTERPOINT.

Henry, Claude (1974). Option Values in the Economics of Irreplaceable Assets. *Review of Economic Studies,* Vol 41, Symposium on the Economics of Exhaustible Resources, 89 -104.

Instream Flow Council (IFC). Instream Flow is the Water Flowing in a Stream Channel. www.darwin.nap.edu. Accessed on September 30, 2006.

Landry, Clay. (1999). Market Transfers of Water for Environmental Protection in the Western United States. *Water Policy, 1,* 457-469.

Litchy, P. Personal communication March 2005.

McNamee, Gregory. 1994 Gila The Life and Death of an American River. University of New Mexico Press, Albuquerque

Meyer, M. Personal Communication. September 8, 2006.

Murphy, M. (2006, October 24). Scientists discuss effects of taking water out of Gila. *Silver City Daily Press,* pp A1, A9.

Nair, S. Personal communication. September 2006.

Neuman, Janet C. (2000) Implementing Instream Flow Protections In Prior Appropriation Systems: Continuing Challenges. *Review of Legal Documents, 7,* 345-351.

New Mexico Interstate Stream Commission. (2006). Briefing on Upper Gila River Settlement Decision Process.

Office of the State Engineer, (2001). New Mexico Water Rights Fact Sheet.

Office of the State Engineer, New Mexico Gila Settlement Questions and Answers. (2005).

Office of Real Property Services, www.orps.state.ny.us, accessed on November 10, 2006.

Pittenger, J. (1993). Gila Trout (Oncorhunchus gialae) (Third Revision) Recovery Plan.

Rice, J., Niemi, E., ECONorthwest. (2005). The Potential Economic Costs of a Gila River Diversion. *ECONorthwest.*

Salmon, D. Personal communication. March 2005.

Shupe, S. (1989). Keeping the waters flowing: stream flow protection programs, strategies and issues in the West. *Instream flow protection in the West.* 1-21.

Siwik, A. (2004). New Mexico and Arizona Reach Agreement on the Gila River Water. *Carapace*, 8, 1-4.

Siwik, A. (January, 2006). Alternative Options to Water Development. *Executive Director of the Gila Conservation Coalition.*

Siwik, A. Personal Communication. January 2006.

Soles, E. (2003). WHERE THE RIVER MEETS THE DITCH: HUMAN AND NATURAL IMPACTS ON TH GILA RIVER, NEW MEXICO, 1880-2000.*Thesis submitted in Partial Fulfillment of the Requirements for the Degree of Master f Arts in Rural Geography.*

SWCA Environmental Consultants. (2006). Upper Gila River Ecological Conditions Analysis, *New Mexico Interstate Stream Commission.* SWCA Project No. 10525-091

The New Mexico Forest and Watershed Health Planning Committee. (2004). The New Mexico Forest and Watershed Health Plan: Integrated Collaborative Approach to Ecological Restoration.

U.S. Department of Energy. (2006). Endangered Species Act and the Fish and Wildlife Coordination Act. http://www.eh.doe.gov. Accessed on 8/31/06.

U.S. Fish and Wildlife Services (1983). Endangered and Threatened Wildlife and Plants; Threatened Status for Gila Nilgrescens (Chihuahua Chub). *Department of the Interior: Fish and Wildlife Services,* 48, 46053- 46057.

U.S. Fish and Wildlife Services (1991). Loach Minnow *Tiaroga cobitis*: Recovery Plan.

U.S. Fish and Wildlife Services (1991). Spikedace *Meda fugida*: Recovery Plan.

U.S. Fish and Wildlife Services (2002). Final Recovery Plan: Southwestern Willow Flycatcher (Empidonax traillii extimus).

U.S. Fish and Wildlife Services (2006)/ Chiricahua Leopard Frog (Rana chiricahuensis), *Draft Recovery Plan.*

Upper Gila Watershed Alliance. Our Watershed Maps & Data. http://www.ugwa.org. accessed February 2006.

USGS (2006). USGS Surface Water data for New Mexico: USGS Surface-Water Annual Statistics. Posted: http://waterdata.usgs.gov.

Ward, F. & Booker, J. (2006). Economic Impacts of Instream Flow Protection for the Rio Grande Silvery Minnow in the Rio Grande Basin. *Reviews in Fisheries Science, 14,* 187-202.

Wheeler, S. Personal communication. October 2006.

Wilson, Brian (2003). Office of the State Engineer's Water Use by Category in New Mexico Counties and River Basins, and Irrigated Acreage Report in 2000, Technical Report 51, 2003.

Appendix A

Appendix A

Guidelines used in Contingent Value Method (Hackett 2001)

1. Clearly identify the contingency to be studied.
2. Perform a pretest and survey with a small focus group.
3. Use these results to create a survey instrument that accurately informs people of the precise nature of the anticipated effects of the contingency using a referendum style format. Therefore the question should ask how the respondent would vote if the environmental improvement would be paid for by specific increase in taxes or higher product prices. Also the survey must clearly state that willingness-to-pay prices will reduce their fund to spend on other goods and services.
4. Use repeated random sampling techniques with different dollar amount for each group surveyed. Personal interviews are better than phone interviews when possible.
5. Analyze the data using relevant statistical techniques to estimate a demand curve (WTP function) that relates to the percentage of "yes" answers to each of the surveyed WTP values using a constant.

Appendix B

Appendix B - Average Stream Flow

USGS 09430500 GILA RIVER NEAR GILA, NM

Year	Mean Q	
1985	422.6	
1986	211.8	
1987	176.6	
1988	264.4	
1989	89.5	
1990	80.5	
1991	308.6	
1992	331.5	
1993	428.4	
1994	75.7	
1995	314	
1996	87.2	
1997	211	
1998	204.1	
1999	103.1	
2000	50.6	
2001	156.2	
2002	59.3	
2003	66.5	
2004	107.1	
2005	346.1	
Annual Mean Discharge	195.0	**cfs**
Annual Mean Discharge	0.004477	**afs**
Annual Mean Discharge	141186.1	**afy**

USGS 09431500 GILA RIVER NEAR REDROCK, NM

Year	Mean Q	
1985	527.5	
1986	266.7	
1987	223.4	
1988	322.9	
1989	107.2	
1990	85.5	
1991	422.1	
1992	525.7	
1993	663.6	
1994	103.8	
1995	486.5	
1996	104.2	
1997	269.9	
1998	279.1	
1999	133.4	
2000	57	
2001	233.5	
2002	76.6	
2003	77.1	
2004	131.5	
2005	420.8	
Annual Mean Discharge	**262.8**	**cfs**
Annual Mean Discharge	**0.00603301**	**afs**
Annual Mean Discharge	**190257.108**	**afy**

Appendix B - Average Stream Flow

USGS 09432000 GILA RIVER BELOW BLUE CREEK, NEAR VIRDEN, NM

Year	Mean Q	
1985	559.6	
1986	328	
1987	215.6	
1988	320.7	
1989	111.2	
1990	75.7	
1991	408.3	
1992	520.3	
1993	745.7	
1994	100.2	
1995	563.9	
1996	129.8	
1997	294.8	
1998	297	
1999	129.3	
2000	62.7	
2001	226.7	
2002	78.3	
2003	78.5	
2004	159.6	
2005	507.7	
Annual Mean Discharge	**281.6**	**cfs**
Annual Mean Discharge	**0.006465536**	**afs**
Annual Mean Discharge	**203897.1433**	**afy**

Appendix C

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
1	Average Monthly and Annual Flows on Gila River Measured in CFS																							
2		1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Monthly Averages	
3	January	329.6	811.4	137.3	169.1	114.3	106.3	83.2	542.8	662.7	2,987	106.3	1,054	83.7	155	189.4	90.4	86.2	143.3	83.9	84.8	93.7	386.4	January
4	February	127.5	749.2	433.1	159.2	388.8	114.7	87.7	346.1	989.6	1,692	156.8	1,296	92.6	207.7	293.8	85.7	73.9	181.7	90	78.7	76.6	367.7	February
5	March	121.8	1,209	401.9	353.3	263.8	138.6	124.5	1,280.00	1,123	1,137	199.4	637.1	69.7	607.1	882.5	78.9	81.3	329.2	68.9	193.5	367.2	460.4	March
6	April	128.2	572.5	251.2	373.1	207.8	92.9	92	636.5	918.8	583.3	134.3	187.5	53.7	284.8	723.6	65.8	59.2	248.5	54.4	167.1	504.8	301.9	April
7	May	92.1	398.4	98.7	216.3	126.7	52.2	55.2	238.3	1,068	323.9	77.7	156	25.1	185.3	283.9	44.8	28.3	109.2	31.9	67.6	104.8	180.2	May
8	June	44.2	81.7	53.1	72.7	40.8	21.1	13.4	101.6	277.6	109.7	29.8	66	17.9	57.5	90.9	35.9	25.1	33.6	12.8	22.3	31.8	59.0	June
9	July	67.4	54.6	286.9	79.9	107.5	49	72.9	104.5	98	59.9	24.2	72.7	111	67.1	140	128	33.2	55.6	36.5	17.3	31.8	80.9	July
10	August	277.5	123.6	240.1	380	1,182	118.8	135	581.2	160.6	236.7	40.9	182.7	225	216.9	145.1	530.4	21.6	213.6	85.5	26.1	87.1	248.1	August
11	September	115.9	64.4	157.3	99.5	1,221	99.3	118.9	623.2	85.6	187.3	118.4	108.5	355.6	929	65.7	221.1	22.9	107.4	209.1	32.1	58.3	238.1	September
12	October	124.5	755.4	210.8	65.4	249.9	83.5	122.1	93.2	68.7	113.3	47.5	56.2	216	190.6	68.8	82.2	447.7	86.9	66.7	38.4	92.4	156.2	October
13	November	84.9	189.1	279.4	83.2	135.4	76.8	114.7	130.3	86.5	130.6	911.5	84.6	204	122.3	115.4	84.7	771.9	79	76.9	103.7	115	189.5	November
14	December	2,036	198.4	278.9	86.8	107	81.5	359.3	707.8	536.2	118.4	1,175	77.6	115	219.6	128.3	85.2	163	83.6	91.5	82	145.3	327.4	December
15	Yearly Average	295.8	433.975	235.725	178.2083333	345.4166667	86.225	114.9083333	448.7916667	506.275	639.925	251.8166667	331.575	130.775	270.2416667	260.6166667	127.7583333	151.1916667	139.3	75.675	76.13333333	142.4		
16																								
17	Criteria for Flows for Fish Habitat by Year																							
18	Average Annual Q from 1984 -2004	249.7																						
19	Excellent Fish Habitat	74.9	30%																					
20	at least 30 - 50% mean annual Q	124.8	50%																					
21	Outstanding Fish Habitat	99.9	40%																					
22	at least 40 - 60% of mean annual Q	149.8	60%																					
23	Optimum Fish Habitat	149.8	60%																					
24	at least 60 - 100% of mean annual Q	249.7	100%																					
25																								
26																								
27	Flows for Fish Habitat by Season																							
28	Winter Months	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Monthly Averages	
29	October	124.5	755.4	210.8	65.4	249.9	83.5	122.1	93.2	68.7	113.3	47.5	56.2	216	190.6	68.8	82.2	447.7	86.9	66.7	38.4	92.4	156.2	October
30	November	84.9	189.1	279.4	83.2	135.4	76.8	114.7	130.3	86.5	130.6	911.5	84.6	204	122.3	115.4	84.7	771.9	79	76.9	103.7	115	189.5	November
31	December	2,036	198.4	278.9	86.8	107	81.5	359.3	707.8	536.2	118.4	1,175	77.6	115	219.6	128.3	85.2	163	83.6	91.5	82	145.3	327.4	December
32	January	329.6	811.4	137.3	169.1	114.3	106.3	83.2	542.8	662.7	2,987	106.3	1,054	83.7	155	189.4	90.4	86.2	143.3	83.9	84.8	93.7	386.4	January
33	February	127.5	749.2	433.1	159.2	388.8	114.7	87.7	346.1	989.6	1,692	156.8	1,296	92.6	207.7	293.8	85.7	73.9	181.7	90	78.7	76.6	367.7	February
34	March	121.8	1,209	401.9	353.3	263.8	138.6	124.5	1,280.00	1,123	1,137	199.4	637.1	69.7	607.1	882.5	78.9	81.3	329.2	68.9	193.5	367.2	460.4	March
35	Yearly Average	470.7	652	290.2	152.8	209.9	100.2	148.6	516.7	577.8	1029.7	432.8	534.3	130.2	250.4	279.7	84.5	270.7	150.6	79.65	96.9	148.4		
36																								
37	Criteria for Flows for Fish Habitat in Winter																							
38	Average Q from 1984 - 2004	416.5																						
39	Good Habitat	83.3	20%																					
40	never falls below 20% of mean annual Q																							
41																								
42	Summer Months	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Monthly Averages	
43	April	128.2	572.5	251.2	373.1	207.8	92.9	92	636.5	918.8	583.3	134.3	187.5	53.7	284.8	723.6	65.8	59.2	248.5	54.4	167.1	504.8	301.9	April
44	May	92.1	398.4	98.7	216.3	126.7	52.2	55.2	238.3	1,068	323.9	77.7	156	25.1	185.3	283.9	44.8	28.3	109.2	31.9	67.6	104.8	180.2	May
45	June	44.2	81.7	53.1	72.7	40.8	21.1	13.4	101.6	277.6	109.7	29.8	66	17.9	57.5	90.9	35.9	25.1	33.6	12.8	22.3	31.8	59.0	June
46	July	67.4	54.6	286.9	79.9	107.5	49	72.9	104.5	98	59.9	24.2	72.7	111	67.1	140	128	33.2	55.6	36.5	17.3	31.8	80.9	July
47	August	277.5	123.6	240.1	380	1,182	118.8	135	581.2	160.6	236.7	40.9	182.7	225	216.9	145.1	530.4	21.6	213.6	85.5	26.1	87.1	248.1	August
48	September	115.9	64.4	157.3	99.5	1,221	99.3	118.9	623.2	85.6	187.3	118.4	108.5	355.6	929	65.7	221.1	22.9	107.4	209.1	32.1	58.3	238.1	September
49	Yearly Averages	120.9	215.9	181.2	203.6	481.0	72.2	81.2	380.9	434.8	250.1	99.9	128.9	131.4	290.1	241.5	171.0	31.7	128.0	71.7	55.4	136.4		
50																								
51	Criteria for Flows for Fish Habitat in Summer																							
52	Average Q from 1984 - 2004	186.1																						
53	Good Habitat	74.4	40%																					
54	never falls below 40% of mean annual Q																							

Appendix D

Appendix D - Projection for Fish Habitat

Projected Use vs. Historical Flows

Monthly Averages			**Projected Monthly Averages**	**AF converted to CFS**	**Quality of Fish Habitat**	
(historical flows)			(depletions have been subtracted)	60 AF/ M= 1 CFS/ M		
				724 AF/ M = 1 CFS / Y	**(based on rule of thumb)**	
CFS	**Month**	**Percentage**	**AF**	**CFS**	**Winter**	**Summer**
386	January	13%	12578	209.6	good	
367	February	12%	11959	199.3	good	
460	March	15%	14990	249.8	good	
301	April	10%	9809	163.5		good
180	May	6%	5866	97.8		good
59	June	2%	1923	32.0		poor
80	July	3%	2607	43.4		poor
248	August	8%	8082	134.7		good
238	September	9%	7756	129.3		good
156	October	5%	5084	84.7	marginally good	
189	November	6%	6159	102.6	good	
327	December	11%	10656	177.6	good	
2991.0	yearly total	100%	97467	134.6		

Legend

AF =	Acre-foot
CFS =	Cubic Feet per Second
M =	Month
Y =	Year

CFS	**Month**	**Percentage**	**AF**	**CFS**	**Winter**	**Summer**
386	January	13%	12578	209.6	good	
367	February	12%	11959	199.3	good	
460	March	15%	14990	249.8	good	
301	April	10%	9809	163.5		good
180	May	6%	5866	97.8		good
59	June	2%	1923	32.0		poor
80	July	3%	2607	43.4		poor
248	August	8%	8082	134.7		good
238	September	9%	7756	129.3		good
156	October	5%	5084	84.7	marginally good	
189	November	6%	6159	102.6	good	
327	December	11%	10656	177.6	good	
2991.0	yearly total	100%	97467	134.6		

Appendix D - Projection for Fish Habitat

Ranges of flows (cfs) for Fish Habitat		
Time	Condition	Flows (CFS)
Winter	good	never below 83
Oct - March		
Summer	good	never below 74
April - Sept		
Yearly Average	excellent	75 - 125
	outstanding	100 - 150
	optimum	150 - 250

Appendix E

Appendix E - Projected Water Use

	Past SW Withdrawals	**Projected Water Use (AFY)**				*Past SW Withdrawals*	**Projected Water Use (AFY)**				*Past SW Withdrawals*	**Projected Water Use (AFY)**				*Past SW Withdrawals*	**Projected Water Use (AFY)**			
County	**Catron County**					**Grant County**					**Hidalgo**					**Luna**				
Year	2000	2010	2020	2030	2040	2000	2010	2020	2030	2040	2000	2010	2020	2030	2040	2000	2010	2020	2030	2040
Growth Rate		**1.15 (high)**	**0.57 (high)**	**.13 (high)**	**0.11 (high)**		-0.5 (high)	1 (high)	1 (high)	1 (high)		1.26 (high)	0.53 (high)	0.05 (high)	0.01 (high)					
commercial	41	46	49	49	50	242	230	3,030	3347	3,697	512	580	612	615	616	186	238	293	343	387
industrial	8	8	8	8	8	11	18	24	27	27	6	7	7	8	9	55	90	133	178	217
mining	0	1000	1000	1000	1000	21,458	38,000	38,000	38,000	38,000	4,332	433	433	433	433	41	41	41	41	41
power	0	0	0	0	0	280	280	280	280	280	0	720	720	720	720	0	1,120	2203	2203	2203
irrigated land	19,963	22764	22,764	22,764	22,764	29,871	31,272	31,272	31,272	31,272	41,884	57,247	57,247	57,247	57,247	114,183	114,183	114,183	114183	114183
livestock	332	349	367	386	405	419	440	463	487	511	320	1,131	1,189	1,250	1314	424	446	468	492	518
domestic	268	301	318	322	326	923	876	968	1070	1,182	200	226	239	240	240	676	866	1065	916	1408
total use	20612	24468	24506	24529	24553	53204	71116	74,037	74483	74,969	47254	60344	60447	60513	60579	115565	116984	118386	118356	118957
66% is return flows	13603.92	16148.88	16173.96	16189.14	16204.98	35114.64	46936.56	48864.42	49158.78	49479.54	31187.64	39827	39895.02	39938.58	39982.14	76272.9	77209.44	78134.76	78114.96	78511.62
depletion	7008.08	8319.12	8332.04	8339.86	8348.02	18089.36	24179.44	25,173	25324.22	25,489	16066.36	20516.96	20551.98	20574.42	20596.86	39292.1	39774.56	40251.24	40241.04	40445.38

How I arrived at 3 to 1 ratio		Total surface water withdrawals	Total	Total
Water Use in 2000		SE Region	Return Flow	Depletion
SW New Mexico		77,331	55,631	21,700
(Wilson et al, 2003 cited in DB Stevens 2004)				

	Total depletions (AFY)				
	Year	2010	2020	2030	2040
	Catron	8319.12	8332.04	8339.86	8348.02
	Grant	24179.44	25173	25324	25489
	Hidalgo	20516.96	20551.98	20574.42	20596.86
	Luna	39774.56	40251.24	40241.04	40445.38
	total depletions (AFY)	92790.08	96328.26	96509.32	96919.26
	Average AFY in Gila River	190,257.11	190,257.11	190,257.11	190,257.11
	total depletions (AFY)	92790.08	96328.26	96509.32	96919.26
	difference (AFY) = what is in river	97,467	93,929	93,748	93,338