Water Resources Research Center

Annual Technical Report

FY 1998

Introduction

Research Program

ANNUAL REPORT Fiscal Year March 1998-February 1999 Program Report Federal Grant Number 1434-HQ-96-GR-02657 Prepared By Arizona Water Resources Research Center The University of Arizona Tucson, Arizona 85721 _____ _____ _____ The program for Arizona was regional during this period and administered by the University of Wyoming. Information provided is as complete as possible given that the Wyoming administration dissolved and information was not given to the individual state centers. CONGRESSIONAL DISTRICTS FOR "DECISION SUPPORT SYSTEM FOR RIVER SYSTEM MANAGEMENT UNDER HYDROCLIMATIC VARIABILITY" 5th Congressional District, Arizona; Valdes and Lansey 1st Congressional District, Oregon; Koch 22nd Congressional District, California; Loaiciga

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Decision Support System For River System Management Under Hydroclimatic Variability
Project Number	C-98-01
Start Date	03/01/1998
End Date	02/28/1999
Research Category	Climate and Hydrologic Processes
Focus Category #1	Water Supply
Focus Category #2	Management and Planning
Focus Category #3	Surface Water
Lead Institution	The University of Arizona

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Juan B. Valdes	Professor	The University of Arizona	01
Kevin Lansey	Associate Professor	The University of Arizona	02
Roy Koch	Professor	Portland State University	03
Hugo Loaiciga	Professor	University of California-Santa Barbara	04

Problem and Research Objectives

Management of large river/reservoir systems is typically very conservative as a result of the broad impact of decisions and failures. A significant cause of this conservatism is the uncertainty of future inflows. Since major decisions have a long period of influence, operators oftentimes base decisions on streamflows that are less than the average flow in order to provide a safety factor during operations. As a consequence, decisions may be far from the optimal policy, if perfect forecasts were available, and result in spillages that do not contribute to meeting project objectives. This project focuses on developing a decision support system (DSS) to assist decision makers improve reservoir and river basin management by adapting to varying climate conditions. The DSS will include components to produce forecasts and analyze the impact of an operation policy under different sets of forecasts either by simulation or by developing an optimal operation policy. The forecasting models will predict flows on the order of one year in advance. A critical issue in water management in the western US is the influence of the El Niño-Southern Oscillation (ENSO). The interannual and intraannual hydroclimatic variability resulting from the ENSO is seen to varying degrees in different western states. It has been shown to have a particularly profound impact on the northwest. Preliminary analysis of data from Arizona and California also shows that significant variations occur during years when ENSO impacts the local climate. Thus, the forecasting tools will attempt to account for the ENSO influence while still maintaining forecast quality for one-year forecasts on a monthly time step.

Methodology

Management of large water resources projects is strongly influenced by long term weather conditions and hydroclimatic variation. More accurate streamflow forecasts will result in better operational planning. Reservoir operation decisions, in particular, can take advantage of improved forecasts, by allocating storage and releases in anticipation of likely events. For example, in the fall of 1997 the Salt River Project, recognizing the strongly developing ENSO, began supplying users from their surface water reservoirs rather than from groundwater sources. The decision was based on the likelihood of high flows but was not based on quantitative forecasts. The risk involved potentially not re-filling the reservoir this spring. Their decision was successful with higher than average snowfall that brought reservoirs to acceptable levels. The result is a long-term gain in overall aquifer storage and on the order of a million dollars in reduced pumping costs. Additional lead time and more accurate forecasts of the influence of ENSO could further improve their operation policies on an annual basis. This project, in part, focuses on methodologies for improving hydrologic forecasts. However, it is critically important that beneficial products of advanced research are passed to the practicing community. Therefore, this proposal is centered about the development of a decision support system (DSS) to assist system managers in situations, like the one noted above, and improving their operational planning. Three primary objectives will be pursued in the development and application of the DSS. They are to: 1) Develop an improved methodology for making streamflow forecasts for the western

US considering ENSO influences; 2) Examine the influence of forecasts on reservoir system management; and 3) Provide an operator friendly interface for comparing operational plans and determining optimal policies, based on the improved forecasts. As noted, forecasts of likely future events can be invaluable in planning under uncertainty. The work in this aspect of the project will be to develop a data fusion system that will incorporate 1) forecasted ENSO; 2) other variables including snow water equivalents; 3)persistence-based forecasts; and 3) up-to-date observations. The resulting operational model will be based upon the Kalman filter method and produce streamflow forecasts and error bounds on the forecasts. The influence of forecasts and their uncertainty on river system management will be studied on three systems. The first is the Salt River Project on the Salt and Verde rivers in Arizona. This system is operated primarily for water supply for the Phoenix metropolitan area. The Sacramento/American River system in northern California supplies water to the Central Valley and South Coast regions of California and is the second system in our proposed study. The reservoirs in this system are operated for multiple purposes. The third system is the Lewis River in the Pacific Northwest. These systems are in different climate regions and are operated for different purposes; as such the utility of forecasts and the uncertainty of the forecasts may vary. Data has been collected on each system including reservoir capacities, historical streamflow, and operation policies. Using these systems as a basis, a series of questions will be considered through simulations. The questions include: 1) How should management decisions be changed during ENSO influenced years versus non-ENSO years? 2) How are management decisions affected by differing system characteristics, climatic conditions and objectives under ENSO influenced years? 3) How will the time increment of forecasts (e.g. months or seasons) affect uncertainty and management decisions? 4) How will the initiating period of forecasts affect management decisions? To address these questions, the tradeoff between forecast error in future streamflows as measured by the root mean square error and the increase in return from the system as compared to the present operation scheme. A comparison can also be made between the forecasting uncertainty and the variability in the objective function at the optimal solution.

Principal Findings and Significance

Year One Progress To efficiently make these comparisons described above, a DSS is being developed. This interface allows users to alter data, execute each component of the DSS and review results. A Windows-based button-oriented interface will be developed to provide users with limited experience apply the models to a general system with minimal training. The DSS is in progress with the simulation being completed, the optimization model underway and forecasting tools progressing. In addition, a preliminary user interface is complete. Simulation is a mass balance analysis under a defined operation policy. The reservoir storage and project benefits over time are computed. A general reservoir configuration is defined for up to three reservoirs and the specific cases for the reservoir systems under consideration in this project. The optimization routine will use nonlinear programming to determine the expected return functions in the future. These functions will then be used to make short term decisions given the streamflow forecasts (discussed below). The simulation and optimization methods will provide tools to compare forecasts' values. Streamflow forecasting on a monthly basis is being computed by two methods that will be compared based on their forecast skill. In essence, the first method will develop forecasts on a monthly basis using data describing the system. These forecasts will be updated during the season. The second method will make seasonal forecasts then disaggregate these forecasts to monthly values. General computer programs for each approach are nearly complete and streamflow and precipitation data is now being analyzed. The next year's effort will focus on completing the above tasks and linking the forecasts with the simulation/optimization methods. The forecast value will then be assessed as described earlier.

Descriptors

Reservoir Management, Hydroclimatology, Stochastic Hydrology, Mathematical Models, Optimization, Arid Climates

Articles in Refereed Scientific Journals

There are several papers in preparation that will be submitted before the end of this project.

Book Chapters

None

Dissertations

In Preparation

Water Resources Research Institute Reports

None

Conference Proceedings

Papers in Proceedings Valdés, J.B., D. Entekhabi, H-M Shin and H-H Hsieh," An Evaluation of the Impact of ENSO on the Discharges of the Salt River, Arizona," Proceedings of the 26th Annual Conference of the ASCE Water Resources Planning and Management Division, Tempe AZ, June 1999. Conferences Valdés, J.B., D. Entekhabi and H-H Hsieh, "Analysis of the Impact of the 1997-98 ENSO Episode on the Southwest Hydrometeorology," Invited, American Geophysical Union 1998 Fall Annual Meeting, San Francisco CA, December 1998. Koch, R.W. and A.R. Fisher, " Interannual and decadal scale hydroclimatic variability of a western Cascades watershed," American Geophysical Union 1999 Fall Annual Meeting, San Francisco CA, December 1999

Other Publications

None

Information Transfer Program

The purpose of the WRRC Information Transfer Program is to communicate information and research results about Arizona's water resources to a broad audience including researchers, the water community, school-age children and especially the public. During this time frame the water crisis in Tucson and Arizona deepened the issue of using Central Arizona Project water was being presented to voters for decision, water conservation information was disseminted and information was needed to inform about the safe yield goal. WRRC in support of these areas published 3 newsletters; built and maintained web sites; developed an electronic kiosk; produced water expertise directories; developed a water conservation alliance; sponsored or co-sponsored conferences, symposia and workshops; continued Water Education for Teachers; developed K-12 curricula; maintained a public information and referral service for answering or redirecting water-related question from the interested

public, public officials and agency personnel, as well as providing speakers and presentations on water issues as requested. Newsletters: "El Nino News", "Arroyo" and "Arizona Water Resource" are aimed at different audiences. These are sent at no charge to a subscriber list of approximately 2800 names in Arizona, the United State and several foreign countries. Web sites: WRRC provides extensive water information through its own web site and through development of web sites for statewide agencies. Websites have been developed for the Arizona Department of Water Resources, the Arizona Water Bank and the Arizona Water Protection Fund. The WRRC website makes available all newsletters, announcement and directories available in searchable format. Undergraduate student help was essential in all these efforts. Electronic kiosk: WRRC produced electronic kiosks utilizing touch-screen monitors to disseminate information on water conservation and water-effcient landscape plants. Kiosks are placed at botanical gardens, plant nurseries, municipal and local water companies and at special events such as plant and home shows. Water Expertise Directory: "Where to Find Water Expertise at State Universities in Arizona" was revised (3rd edition) and published in early winter 1998. This publication provides basic information about 201 people at the three Arizona state universities with expertise in water related areas. The areas covered include ecology, hydrology, agricultural economics, flood control, water pollution and many other fields. It is also available in searchable format on the web site. "Where to Get Free (or almost Free) Information about Water in Arizona" was revised (4th edition) and published in the summer of 1998. This publication provides information about water-related government agencies, non-profit organizations, private water companies, and professional associations in Arizona. Both directories are widely distributed to libraries, schools, government agencies and others throughout the state. In the fall of 1998, WRRC staff began work on a major project to provide a comprehensive summary of water information for the Tucson area. This area has been experiencing a great deal of conflict over water rsources decision making. The purpose of the project, which culminated in a publication and web site materials in the summer of 1999, was to provide objective information as a basis for community discussion and decision making. During this period WRRC continued to work on projects for the Arizona State Land Department. The purpose was to gather historic information on Arizona's rivers to assist in determining streambed ownership, under a U.S. Supreme Court decision. Barbara Tellman developed information on specific rivers, compiled a history of boating in Arizona, and helped develop criteria for determining potential navigability of minor watercourses. Water Conservation Alliance: The Water Conservation Alliance of Southern Arizona (Water CASA) was formed to provide a means for member water providers to augment their individual conservation programs and to improve the region's overall water conservation efforts. Water CASA's membership includes Metro Water District, Avra Water Co-op, Community Water Company of Green Valley, Flowing Wells Irrigation District, the Town of Marana, Pima County Wastewater Management and the U.S. Bureau of Reclamation. This alliance has become a productive organization by providing a pro-active, unified voice on water conservation issues with other municipal providers, and through the development of literature and projects that apply regionally among the participating water providers. It also has undertaken research projects aimed at evaluating conservation measures and increasing the cost effectiveness of water conservation programs. Welcome Packets – Water CASA provides its members with a variety of brochures and information pieces that are distributed in Welcome Packets for new water customers. Water CASA developed the literature in the packets. Members distribute more than 300 packets a month to their new customers and also to customers who request conservation information. We are tracking water use patterns related to the packets to analyze the effectiveness of the Welcome Packet program. Conservation Devices - Bulk orders of conservation devices continue to be made for, and divided among, the members of Water CASA. We are able to purchase conservation devices at the substanially lower prices with our bulk ordering. These conservation devices are included in Welcome Packets for new customers moving into older homes and are also available to water customers on request. Field staff who respond to customer questions or complaints also hand out devices. ADWR Grant on Exterior Conservation - This year Water CASA completed a grant to assess the characteristics of Water CASA members and determine which conservation programs would best benefit each individual provider. The study also identified areas where economies of scale and similar provider characteristics offered the greatest potential for providers to pursue conservation measures as a group. Graywater Project - Water CASA has identified residential graywater reuse as having huge conservation potential. The Alliance was awarded a grant in 1998 to look at actual "wildcat" graywater systems throughout Pima County. The study is to determine

how many people are currently using their graywater and to what extent, establish how they are capturing and using their graywater, and establish whether there are health risks associated with these systems. If increased health risks are not found with existing graywater systems, Water CASA will work toward easing regularions on graywater reuse systems. Ordinances – At the request of Pima County, Water CASA drafted and submitted to the County ten potential water conservation ordinances. Pima County wishes to be pro active in efforts to conserve groundwater and most members of Water CASA do not have authority to institute ordinances so it was an effective effort for all concerned. We have worked closely with County staff in Planning & Zoning to develop the specific ordinance language. Draft ordinances include a xeriscape standard, a water waste ordinance, ordinances for new residential, multi-family and nonresidential construction to limit water intensive landscaping, a requirement for multi-family complexes to ensure their landscape irrigation meets the proper standard upon resale, and a requirement for new subdivisions to construct a community pool in order to discourage individual pools. Safe Yield Dialogue - Water CASA has promoted the need to develop a dialogue within the region and throughout the State to look at overall effective water management. Out of Water CASA came a larger group that looked at the overall ways to address safe yield issues. Dual (or Sub-) Metering Project - WATER CASA believes the greatest conservation potential exists with exterior water usage, but data is lacking to determine what portion of total residential water use occurs outdoors. As a way to obtain the needed data, WATER CASA has outlined a project in which a new subdivision would be designed with separate meters at each residence to track indoor and outdoor water use. News Articles & Press Releases - Press releases and news articles have been drafted and used by Water CASA members throughout this past year. Demonstration Gardens - Water CASA assists members to develop public, low-water-using demonstration gardens in their service areas. A garden for the front of the Avra Water Co-op has been designed and an irrigation plan developed. Metro Water had a garden designed and installed this fall. The installation included a series of public events to illustrate drip irrigation installation and proper desert planting and maintenance techniques. Individual Member Services - Water CASA assisted with the development of the exterior self-audit for Metro Water to satisfy one of the Reasonable Conservation Measures prescribed by ADWR for participation in the Non-Per Capita Conservation Program. Tehy aslo assisted 2 members in designing new rate structures. Colonia Status & Program Development - Water CASA has begun working with members who qualify for Colonia designation. Colonia designation is a program of the USDA which provides federal grants and loans for low-income areas to do infrastructure and other economic improvements. Specifically, we hope to obtain funding for a comprehensive program to retrofit older houses with water conservation devices. Water Education For Teachers: WRRC has an ambitious and productive K-12 water education program, known as Arizona WET (Water Education for Teachers). WRRC staff creates and provides state-specific, interdisciplinary, and supplementary water education materials. These materials are utilized by public and private schools, youth groups, tribal governments, community colleges and state universities. In addition to creating K-12 resources, WRRC is responsible for providing statewide teacher training.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	The Future of Arid Grasslands: Identifying Issues, Seeking Solutions
Description	USDA Forest Service Proceedings RMRS-P-3. Edited by Barbara Tellman, WRRC, and Deborah Finch, Carl Edminster, and Robert Hamre, USDA Forest Service Rocky Mountain Research Station. Ft. Collins CO.
Start Date	01/01/1995
End Date	07/01/1998
Type	Publications
Lead	Water Resources Research Center

Institution	

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Carl Edminster	Professional Staff	USDA Forest Service Rocky Mountain Research Station	01
Deborah Finch	Professional Staff	USDA Forest Service Rocky Mountain Research Station	01
Robert Hamre	Professional Staff	USDA Forest Service Rocky Mountain Research Station	01
Barbara Tellman	Professional Staff	The University of Arizona	01

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Basic Project Information	
Category	**Data**
Title	Final Report on the Arizona Stream Navigability Study for the Virgin River in Arizona
Description	Prepared for the Arizona State Land Dept. Phoenix AZ by JE Fuller/Hydrology and Geomorphology, Inc.; SWCA Environmental Consultants; and WRRC.
Start Date	01/01/1997
End Date	12/01/1998
Type	Publications

Type	Publications
Lead Institution	The University of Arizona

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Barbara Tellman	Professional Staff	The University of Arizona	01

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Basic Project Information	
Category	**Data**
Title	Criteria for Assessing Characteristics of Navigability for Small Watercourses in Arizona:colon; Final Report
Description	Prepared for the Arizona State Land Dept. Phoenix AZ by Stantech Consulting, Inc.; JE Fuller/Hydrology and Geomorphology, Inc.; and WRRC
Start Date	01/01/1997
End Date	09/01/1998
Type	Publications
Lead Institution	Other

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Barbara Tellman	Professional Staff	The University of Arizona	01

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Basic Project Information	
Category	**Data**
Title	Brief History of the Lower Colorado River
Description	Prepared for the Arizona State Land Dept. Phoenix AZ as part of the Lower Colorado Boundary Study, in press
Start Date	01/01/1997
End Date	05/01/1998
Type	Publications
Lead Institution	The University of Arizona

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Barbara Tellman	Professional Staff	The University of Arizona	01

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Basic Project Information	
Category	**Data**
Title	Invasive Exotic Species in the Sonoran Region
Description	Barbara Tellman assisted with the planning, organized and ran a session, and provided a moderated plenary session
Start Date	11/01/1997
End Date	05/01/2000
Type	Conferences
Lead Institution	Arizona Sonora Desert Museum

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Barbara Tellman	Professional Staff	The University of Arizona	01

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Basic Project Information	
Category	**Data**
Title	Where To Find Water Expertise at State Universities in Arizona
Description	This publication provides basic information about 201 people at the three Arizona State Universities. This is the 3rd edition.
Start Date	01/01/1998
End Date	01/01/1999
Type	Publications
Lead Institution	The University of Arizona

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Barbara Tellman	Professional Staff	The University of Arizona	01

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Basic Project Information	
Category	**Data**
Title	Annual Statewide Conference of the Arizona Hydrological Society
Description	Barbara Tellman assisted with the planning, organized and ran a session, and provided a moderated plenary session
Start Date	01/01/1998
End Date	09/01/1998
Type	Conferences
Lead Institution	Arizona Hydrological Society

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Barbara Tellman	Professional Staff	The University of Arizona	01

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Category	**Data**
Title	El Nino News -Arizona Water Resource Newletter
Description	4 pages of updates featuring the current weather phenemenon occuring and affecting Arizona weather and water levels.
Start Date	02/01/1998
End Date	02/01/1998
Type	Newsletter
Lead Institution	The University of Arizona

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Joseph Gelt	Professional Staff	The University of Arizona	01

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Basic Project Information	
Category	**Data**
Title	Water and Natural Areas - Opportunities to Save What's Left
Description	Barbara Tellman in Celebrating Arizona's Unique Heritage: Cultural, Historical and Environmental Perspectives. Ed by. Robert Ashcraft and Carlton Yoshioka, Arizona State University
Start Date	03/01/1998
End Date	05/01/1998
Type	Publications
Lead Institution	Other

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Barbara Tellman	Professional Staff	The University of Arizona	01

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Basic Project Information	
Category	**Data**
Title	Emerging Water Issues In Rural Arizona: Water On The Web
Description	Workshop for personnel from Extension offices throughout the State of Arizona. Workshop notebook was distributed to extension offices statewide.
Start Date	03/28/1998
End Date	04/29/1998
Type	Conferences
Lead Institution	Water Resources Research Center

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Gary Woodard	Research Associate	The University of Arizona	01
Barbara Tellman	Professional Staff	The University of Arizona	02
Joseph Gelt	Professional Staff	The University of Arizona	03
Kenneth Seasholes	Professional Staff	The University of Arizona	04

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Basic Project Information	
Category	**Data**
Title	Where to Get Free (or almost free) Information about Water in Arizona, 4th edition
Description	WRRC publication
Start Date	04/01/1998
End Date	11/01/1998
Type	Publications
Lead Institution	The University of Arizona

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Barbara Tellman	Professional Staff	The University of Arizona	01

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Basic Project Information	
Category	**Data**
Title	Arroyo
Description	12 page newsletter focus on microbes as emerging contaminants
Start Date	05/01/1998
End Date	05/01/1998
Type	Newsletter
Lead Institution	The University of Arizona

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Joseph Gelt	Professional Staff	The University of Arizona	01

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Basic Project Information	
Category	**Data**
Title	Riparian Restoration in the Gila River Basin
Description	Conference organized by the WRRC, USGS Midcontinent Ecological Services Office, and the Rincon Institute with funding from the US Bureau of Reclamation. Barbara Tellman was the main organizer and proceedings editor. Conference held April 1999. Proceedings published Nov. 1999.
Start Date	06/01/1998

Start Date	06/01/1998
End Date	11/01/1999
Type	Conferences
Lead Institution	US Geological Survey

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Barbara Tellman	Professional Staff	The University of Arizona	01

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Basic Project Information	
Category	**Data**
Title	El Nino News
Description	4 page newsletter summarizing the effects of El Nino and posssbile transisiton into La Nina
Start Date	06/01/1998
End Date	06/01/1998
Type	Newsletter
Lead Institution	The University of Arizona

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Joseph Gelt	Professional Staff	The University of Arizona	01

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Basic Project Information	
Category	**Data**
Title	Arizona Water Resource
Description	12 page newsletter presenting generalnews, events and issues analysis for Arizona water community. Focus of this issue was on Safe Yield goal for water and the possibilities of meeting that goal
Start Date	09/01/1998
End Date	10/01/1998
Type	Newsletter
Lead Institution	The University of Arizona

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Joseph Gelt	Professional Staff	The University of Arizona	01

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Category	**Data**
Title	El Nino News Supplement
Description	4 page insert in Arizona Water Resource Newsletter of subjects that El Nino affected and on going impact of this weather phenomenon
Start Date	09/01/1998
End Date	10/01/1998
Type	Newsletter
Lead Institution	The University of Arizona

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Joseph Gelt	Professional Staff	The University of Arizona	01

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USGS Internship Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	3	N/A	N/A	N/A	3
Masters	1	2	N/A	N/A	3
Ph.D.	N/A	2	N/A	N/A	2
Post-Doc.	N/A	N/A	N/A	N/A	N/A
Total	N/A	N/A	N/A	N/A	N/A

Awards & Achievements

None

Publications from Prior Projects

Articles in Refereed Scientific Journals

None

Book Chapters

None

Dissertations

None

Water Resources Research Institute Reports

None

Conference Proceedings

None

Other Publications

None