

**New Mexico Water Resources Research Institute
Annual Technical Report
FY 2012**

Introduction

This program report provides the required information for projects funded with the 2012 base grant and mandatory non-federal matching funds. Please note that there may be some overlap in information with our 2011 report because data collection is based on a July-June fiscal year rather than the March-February USGS Grant Award period.

The New Mexico Water Resources Research Institute (NMWRRI) was established in 1963 by the New Mexico State University Board of Regents, becoming one of the first of the 54 state institutes approved nationwide under the authorization of the 1964 Water Resources Research Act. It is considered to be the statewide nucleus for coordinating water resources research. Using the expertise of researchers in a variety of disciplines at state-supported universities, the institute is able to respond to the critical water needs of New Mexico and the region. It operates under the general advice of a Program Development and Review Board, whose membership includes faculty representatives as well as state and federal agency personnel.

The mission of the NMWRRI is to develop and disseminate knowledge that will assist the state, region, and nation in solving water resources problems. Specifically, the institute encourages university faculty statewide to pursue critical areas of water resources research while providing training opportunities for students who will become our future water resources scientists, technicians, and managers. It provides an outlet for transferring research findings and other related information to keep water managers and the general public informed about new technology and research advances. In addition, the institute maintains a unique infrastructure that links it with many federal, state, regional, and local entities to provide expertise and specialized assistance.

The institute maintains a dynamic program to transfer technical information from the producer to the user and the public. Technical publications, newsletters, conferences, press announcements, and presentations keep practitioners aware of new technology and research advances. The NMWRRI homepage (wrri.nmsu.edu) provides online information about the institute, newsletters, technical report series, requests for proposals, upcoming conferences and symposia, links to related entities, and the research reference library.

New Mexico is one of the driest states in the nation, averaging no more than 20 inches of precipitation a year, varying from about 6.5 inches in the Four Corners area to more than 30 inches in the high mountains. The relative humidity is low, resulting in a high rate of evaporation. Summer rain accounts for almost half of the annual precipitation other than in the high mountains. Widely varied precipitation contributes as much to a water allocation problem as water scarcity itself. To compound the situation, New Mexico, like much of the West, continues to suffer from the worst drought in 100 years or longer. As of April 2013, severe and extreme drought covered 94 percent of New Mexico and it has received less than 50 percent of average precipitation since October 2012. By almost any measure, under current trends and trajectories, future water supply will not meet future water demand in the state. According to a recent report prepared in conjunction with the 2012 NM WRRI annual water conference, Decades of relative water abundance in New Mexico and the region, coupled with large growth in local and regional populations and increased consumption, are leading us to a crisis point for water availability for residential industrial, agricultural and environmental uses. The New Mexico Drought Working Group monitors the situation and current Drought Status Reports are available at <http://www.nmdrought.state.nm.us>.

Solving the dire and complex water problems facing New Mexico and the Southwest requires the highest quality research and the NM WRRI is dedicated to assisting in this effort.

Research Program Introduction

The primary objective of the New Mexico Water Resources Research Institute is to maintain a balanced program of research that addresses water issues and problems critical to New Mexico, the region, and the nation. In administering this program, the institute relies on financial support from state appropriations, federal and state agencies, and the USGS Water Resources Research Institute Annual Base Program (USGS 104B).

To make the best use of limited resources, the institute has targeted four areas as high priority for funding: water conservation, planning and management; atmospheric, surface and groundwater relationships; water quality; and utilization of saline and other impaired waters. During the reporting period, four projects received funding from the 2012 Annual Base Program. Three of these projects fit into the water conservation, planning and management category: "WRRI Information Transfer Program," "Geographic Information System for Water Resources Planning," and "Updating the Digital Hydrogeologic-Framework Model of the Mesilla Basin Area with Specific Reference to the Transboundary Aquifer Assessment Project (TAAP)." A water quality project was also funded: "Computational Fluid Dynamics Modeling of Karst Conduit-Matrix Exchanges with Relevance in Contaminant Transport, and Chemical Reactions." In addition, two projects received special funding through the USGS, "Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan," and "Monitoring and Forecasting Climate, Water, and Land Use for Food Production and Business Development in Iraq." Also, the USGS awarded a cooperative agreement for the coordination of the conference "New Water New Energy: A Conference Linking Desalination and Renewable Energy," a joint effort between the NM WRRI and the Bureau of Reclamation.

During the reporting period, March 1, 2012 through February 28, 2013, the NM WRRI administered a total of ten projects dealing primarily with water planning and management issues. The total value of these projects was nearly \$760,000. Dollar amounts per project award ranged from a small wastewater management system evaluation grant of \$3,361 to an international program effort of over \$375,000. During the reporting period, nine projects were conducted at New Mexico State University and one at New Mexico Tech. NMWRRI staff managed nine projects.

Research projects administered by the NMWRRI utilized at least 15 students during the year including undergraduates, masters, and Ph.D. candidates in the disciplines of agricultural economics, civil engineering, engineering technology, hydrology, geography, computer graphics, and kinesiology.

Projects administered by the NM Water Resources Research Institute during the reporting period are listed below. Note that total award value is shown and includes both agency and cost sharing when appropriate, and can include multiyear funding.

Information Transfer Program, USGS 104B \$35,753

Geographical Information System for Water Resources Planning, USGS 104B \$19,135

Computational Fluid Dynamics Modeling of Karst Conduit-Matrix Exchanges with Relevance in Contaminant Transport, and Chemical Reactions, USGS 104B \$16,049

Updating the Digital Hydrogeologic-Framework Model of the Mesilla Basin Area with Specific Reference to the Transboundary Aquifer Assessment Project (TAAP), USGS 104B \$16,167

Monitoring and Forecasting Climate, Water, and Land Use for Food Production and Business Development in Iraq, USGS \$99,119 (year 3)

Research Program Introduction

Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan, USGS
\$375,099 (year 5)

Physical and Social Drivers of Water Sustainability in a Groundwater-Dependent Agricultural Region on the US-Mexico Border, Southwest Consortium for Environmental Research and Policy, SCERP \$29,328

Examination of Risk to Groundwater from Onsite Wastewater Management Systems, EPA/SCERP \$3,361

Chihuahuan Desert Network Administrative Support, National Park Service \$106,040

Coordination of Conference New Water New Energy: A Conference Linking Desalination with Renewable Energy, Bureau of Reclamation \$59,700

Award No. 08HQAG0146 Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan

Basic Information

Title:	Award No. 08HQAG0146 Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan
Project Number:	2008NM114S
Start Date:	9/22/2008
End Date:	9/21/2013
Funding Source:	Supplemental
Congressional District:	2
Research Category:	Climate and Hydrologic Processes
Focus Category:	None, None, None
Descriptors:	Afghanistan, crop growth, agriculture, economics
Principal Investigators:	Alexander Sam Fernald

Publications

1. Gregory Torell, 2010, Economic analysis for improved water management, food security, and rural livelihoods in Afghanistan's Balkh Basin, M.S. Thesis, NMSU Department of Agricultural Economics and Agricultural Business.
2. Gregory Torell, Balkh River Canal System, Afghanistan Decision Support (excel spreadsheet), posted on the web at <http://agecon.nmsu.edu/fward/water/>
3. Torell, G. and F.A. Ward, 2010, Improved Water Institutions for Food Security and Rural Livelihoods in Afghanistan's Balkh River Basin, International Journal of Water Resources Development, 26,4,613-637.
4. Torell, G. and F.A. Ward, 2010, Improved Water Institutions for Food Security and Rural Livelihoods in Afghanistan's Balkh River Basin, International Journal of Water Resources Development, 26,4,613-637.
5. Ward, F.A., 2012. Cost benefit and water resources policy: A survey. Water Policy. 14:250-280.
6. Torell, G. and F.A. Ward, 2010, Improved Water Institutions for Food Security and Rural Livelihoods in Afghanistan's Balkh River Basin, International Journal of Water Resources Development, 26,4,613-637.
7. Ward, F.A., 2012. Cost benefit and water resources policy: A survey. Water Policy. 14:250-280.
8. Shahruh Jalilov, Saud Amer, and Frank Ward, "Reducing Conflict in the Development and Allocation of Transboundary Waters," Eurasian Geography and Economics, April 2013.
9. Abdelaziz Gohar, Saud Amer, and Frank Ward, "Economic Performance of Water Storage Capacity Expansion for Food Security," Journal of Hydrology, January 2013.
10. Frank Ward, Saud Amer, and Fahim Ziaee, Water Allocation Rules in Afghanistan for Improved Food Security, Food Security, November 2013.

Description of problem and research objectives

This is the fifth year of a cooperative agreement with NMSU and USGS in support of the development of reducing food poverty through development of improved irrigation systems and institutions in Afghanistan. Activities have focused on the application and development of techniques for monitoring the physical variables governing crop growth, such as timing and level of precipitation, evapotranspiration and temperature, along with human-related factors such as cropped area, agricultural inputs, and economic indicators.

These data have been integrated into an analysis of policy options for improving farm income, rural food security, and improved livelihoods. Recent work has developed and applied a framework to inform farmers, extension personnel, mirabs, and ministry personnel on uses of land and water resources in the Balkh River Basin to improve farm income and reduce food poverty.

Three journal articles have been published and two more are currently under review summarizing connections between irrigation institutions and food poverty in Afghanistan. The research examined the development of irrigation institutions that could contribute to reducing food poverty by improved water allocation among canals.

Description of methodology

Funding under Agromet has supported the following activities:

Installation of 113 weather observation sites: 1) all 113 observation sites are recording daily rain and snow; 2) 80 of 113 sites are reporting in addition to rain and snow on crops (wheat, rice, barley and maize) and pasture and grazing twice a month (fortnightly forms) including crop condition (all the weather adverse factors, shortage of inputs, weed, pests and diseases infestations) and crop phenological stages (including land preparation) in addition to areas planted (% of the total by agricultural zone), planting and harvesting dates in addition to the expected yields during the agricultural year and final obtained yields after the harvesting; and 3) of 113 sites, 21 sites are complete agrometeorological stations (three observations daily), with 19 classical stations recording 7 weather parameters and 5 automatic stations that can report on up to 20 weather parameters at daily step.

Using weather, hydrologic, agronomic, and economic data, several arrangements for allocating water through an existing network of irrigation canals were analyzed for their impacts on land and water use, farm profitability, and food security at both the canal and basin levels.

Description of principal findings and significance

Findings show that total water supply and institutional arrangements for allocating water during periods of shortages have important influences on farm income and food security. The methods used and results found provide a framework for informing decisions on the sustainable use of land and water for improved food security and rural livelihoods in the developing world's irrigated areas.

An article was recently published in journal *Food Security*, summarizing findings that indicate that a proportional sharing of shortages in periods of drought combined with water trading is the best method for assuring both food security and farm income in the Balkh Basin, Afghanistan.

New work has begun that examines potential economic benefits of additional reservoir storage that could be developed in the Balkh Basin, Afghanistan. That paper was recently published in the *Journal of Hydrology* in January 2013.

Award No. 08HQAG0117 Transboundary Aquifer Assessment Program

Basic Information

Title:	Award No. 08HQAG0117 Transboundary Aquifer Assessment Program
Project Number:	2008NM115S
Start Date:	4/1/2008
End Date:	3/31/2013
Funding Source:	Supplemental
Congressional District:	2
Research Category:	Ground-water Flow and Transport
Focus Category:	Groundwater, None, None
Descriptors:	aquifer assessment, Mesilla Basin, Hueco Bolson, GIS, database,
Principal Investigators:	Alexander Sam Fernald, Phillip J King

Publications

1. Hawley, John W. and Alfredo Granados-Olivas, 2008, Progress Report on Development of an Annotated Bibliography for Transboundary Aquifer Systems of the Mesilla Basin-Paso del Norte Area, New Mexico, Texas (USA), and Chihuahua (MEX), poster presented at the 2008 New Mexico Water Research Symposium, Socorro, NM, August 2008, Symposium Program and Abstracts.
2. Hawley, J.W., B.J. Creel, and B.V.N.P. Kambhammettu, 2009, Digital hydrogeologic-framework model of the San Francisco River basin, west-central New Mexico and east-central Arizona [abstract], Geological Society of America. Abstracts with Programs, 41(7) Session 58-T21 on CD ROM. ISSN 0016-7592.
3. Hawley, J.W., J.F. Kennedy, A. Granados-Olivas, and M.A. Ortiz, 2009, Hydrogeologic framework of the binational western Hueco Bolson-Paso del Norte area, Texas, New Mexico, and Chihuahua. NM Water Resources Research Institute, NM State University, Technical Completion Report 349. 45 p., with 2 plates on CD ROM. <ftp://wrii.nmsu.edu/pub/hueco>
4. Monger, H.C., L.H., Gile, J.W. Hawley, and R.B. Grossman, 2009, The Desert Project: an analysis of aridland soil-geomorphic processes New Mexico State University Agricultural Experiment Station Bulletin 798. 76 p., <http://aces.nmsu.edu/pubs/research/weather-climate/>
5. Creel, B.J., 2010, Research Needs in the U.S. Portion of the Rio Grande Watershed, E.M. Ward and E.A. Barrantes (eds), Journal of Transboundary Water Resources, 01:31-42.
6. Schmid, W., J.P. King, and T. Maddock III, 2010, Conjunctive Surface-Water/Groundwater Model in the Southern Rincon Valley Using Modflow-2005 with the Farm Process, NM Water Resources Research Institute, New Mexico State University, Technical Completion Report No. 351, 65 pp.
7. Servicio Geologico Mexicano, Coordinacion General de Minería, and International Boundary and Water Commission, 2011, Hydrogeological Activities in the Conejos-Medanos/Mesilla Basin Aquifer, Chihuahua, Phase 1. Prepared for the Transboundary Aquifer Assessment Act Project under contract with the New Mexico Water Resources Research Institute and Texas Water Research Institute. Two volumes.
8. Kambhammettu, B.V.N.P., J.P. King and A. Praveena, 2011, Evaluation of mountain-front recharge estimation techniques for Southern New Mexico basins. International Journal of Water Resources and Environmental Engineering, 3(3):66-72.

Award No. 08HQAG0117 Transboundary Aquifer Assessment Program

9. Kambhammettu, B.V.N.P., Chandramouli, S., and King, J.P. 2011. An improved DEM aggregation technique for models with non-uniform resolution. *International Journal of Geomatics and Geosciences*. 1:4:962-970.
10. Kambhammettu, B.V.N.P., Schmid, W., King, J.P., and Creel, B.J. 2011. Effect of elevation resolution on evapotranspiration simulations using MODFLOW. *Ground Water Journal*. doi: 10.1111/j.1745-6584.2011.00852.x.
11. Kambhammettu, B.V.N.P., Chandramouli, S., and King, J.P. 2011. An improved DEM aggregation technique for models with non-uniform resolution. *International Journal of Geomatics and Geosciences*. 1:4:962-970.
12. Kambhammettu, B.V.N.P., Schmid, W., King, J.P., and Creel, B.J. 2011. Effect of elevation resolution on evapotranspiration simulations using MODFLOW. *Ground Water Journal*. doi: 10.1111/j.1745-6584.2011.00852.x.
13. Phanindra Kambhammettu, BVN, J. P. King, and W. Schmid, 2013. Grid Size Dependency of Evapotranspiration Simulations in Shallow Aquifers – An Optimal Approach. Accepted with revisions, *ASCE Journal of Hydrologic Engineering*, Ms. No HEENG-1735.
14. Alley, William M. (ed). 2013. Five-year interim report of the United States-Mexico Transboundary Aquifer Assessment Program: 2007-2012. USGS Open-File Report 2013-1059. 31 pp.
15. Sheng, Z., M. Darr, J.P. King, J. Bumgarner, and A. Michelsen. 2013. Mesilla Basin/Conejos-Médanos Section of the Transboundary Aquifer Assessment Program. In USGS Open-File Report 2013-1059. pp. 19-31.

Description of problem and research objectives

Rapid population growth in the United States-Mexico border region over the last decade has placed major strains on limited water supplies in the region. Rapid growth rates are expected to continue for at least several more decades. Water quantity and quality issues are likely to be the determining and limiting factors affecting future economic development, population growth, and human health in the border region. Increasing use of groundwater resources in the border region by municipal and other water users has raised serious questions concerning the long-term availability of the water supply.

Cooperation between the United States and Mexico in assessing and understanding transboundary aquifers is necessary for the successful management of shared groundwater resources by state and local authorities in the United States and appropriate authorities in Mexico, including management that avoids conflict between the United States and Mexico. While there have been some studies of binational groundwater resources along the United States-Mexico border, additional data and analyses are needed to develop an accurate understanding of the long-term availability of useable water supplies from transboundary aquifers.

The objectives of the Transboundary Aquifer Assessment Program is to collect and evaluate new and existing data to develop high-quality, comprehensive groundwater quantity and quality information and groundwater flow models for the Mesilla Basin aquifer in New Mexico, Texas, and Mexico.

Description of methodology

A review of all previously developed groundwater flow models was conducted last year. This year field studies were used to develop any additional data that are needed to define aquifer characteristics to the extent necessary to enable the development of groundwater flow models. Additional evaluations of all available data and publications relevant to the aquifer and produce a binational bibliography were conducted. The project utilized the geographic information system database that was created last year to better characterize the spatial and temporal aspects of the aquifer, with emphasis on a digital model of the hydrogeologic framework. The project also continued to expand existing agreements, as appropriate, between the authorities in the United States and Mexico to (1) conduct joint scientific investigations; (2) archive and share relevant data; and (3) carry out any other activities consistent with the program. A basin steering committee of local stakeholders was established to provide review and feedback on tasks and products.

Description of principal findings and significance

A bibliography of previous studies that was compiled in 2008 has been updated and reviewed by the USGS, New Mexico, and Texas team. This is an ongoing process as more literature is found and new literature is written. The basin-scale hydrogeologic

framework model that was produced in 2005, including cross sections and model layer maps, was reviewed and updated with recent information and a new compilation of well-control data. Expansion of this model into Mexico has been proposed and is pending finalization of the binational agreement for conducting joint investigations and basic-data sharing. Mesilla Basin groundwater flow models developed in the last 20 years have been reviewed and evaluated for their possible future use and modification. This evaluation still needs collaborative input from the Mexican authorities before selection of the most appropriate flow model(s) for expansion into Mexico.

The regional hydrology model of the area released by the New Mexico State Engineer in 2007 has been updated through 2009. The new Farm Module feature of MODFLOW has been added to the model and runs are being done to compare the new version with the OSE version.

The basic binational-agreement documents related to conduct of joint investigations and data sharing were signed in August 2009; and specific final arrangements for agreement implementation are planned for completion in March-April 2010.

All final reporting was completed during the current period. The USGS has published results in Open-File Report available online only: Five-year interim report of the United States-Mexico Transboundary Aquifer Assessment Program: 2007-2012, edited by William M. Alley.

USGS Award No. G10AC00516 Monitoring and Forecasting Climate, Water, and Land Use for Food Production and Business Development in Iraq

Basic Information

Title:	USGS Award No. G10AC00516 Monitoring and Forecasting Climate, Water, and Land Use for Food Production and Business Development in Iraq
Project Number:	2010NM123S
Start Date:	9/1/2010
End Date:	8/31/2015
Funding Source:	Supplemental
Congressional District:	2
Research Category:	Climate and Hydrologic Processes
Focus Category:	Drought, Water Use, Management and Planning
Descriptors:	Forecasting, Climate, Water Use, Land Use, Agriculture, Drought
Principal Investigators:	Alexander G. Fernald, Frank Ward

Publication

1. Water Rights Systems for Adapting to Shortage (under review, Journal of the American Water Resources Association)

Brief description of problem and research objectives

This program supports the Iraq Water, Agriculture, Geospatial Data Infrastructure and Technology Transfer Program. Streamflows in the Tigris-Euphrates rivers in Iraq have declined in recent years, and an important policy debate centers in the most economically viable measures for making more economical and business use of those reduced flows in Iraq. The objective of this project is to explore the development of innovative irrigation institutions for allocating water and water rights among water users in Iraq in order to secure more economically productive uses of water in the Tigris-Euphrates basins.

Overall Agromet project objectives are:

- Install Agro-meteorological stations throughout the country
- Set up an operational agro meteorological database and information system functioning efficiently, including all the relevant data (historical and recent)
- Carry out agro climatic analyses for major agro meteorological parameters.
- Provide timely, accurate, and reliable data for decision makers, government agencies, international forces, and national and international NGOs.
- Assist the Iraq Government in their efforts to collect and analyze meteorological and agricultural data as it relates to crop production, irrigation, water supply, energy, dust storms, and aviation.
- Create a transition plan for future implementation by Iraq government officials.
- Play a key role in the institutional capacity building and training of Iraqis in the field of agro- and hydro-meteorology.

Brief description of methodology

- Collecting agro-meteorological data for water and crop monitoring and forecasting
- Collecting meteorological data for dust storm forecasting
- Development of crop monitoring and production estimating tools
- Temperature and photoperiod inputs to yield estimation
- Development of hydroeconomic policy analytic tools
- Improved rainfall forecasts
- Improved understanding of relations between snowpack and streamflow
- Teach short courses in Iraq on the development and use of hydroeconomic spreadsheet models to support policy analysis of irrigation water management in Iraq.

Brief description of principal findings and significance

Climate change and population growth have intensified the search internationally for measures to adapt to fluctuations in water supplies. An example can be found in the Lower Tigris-Euphrates Basin where recent water supply reductions have resulted in high economic costs to farmers. Causes include increased upstream water developments and use, climate impacts, and a weakly developed capacity in the lower basin to adapt to water shortages. Losses to irrigators in the lower basin have made a compelling case to identify flexible methods to adapt to water shortage. Few published studies have systematically examined ways to enhance the flexibility of water right systems to adapt to

water shortages. This paper examines how profitability at both the farm and basin levels is affected by various water allocation methods. Four water allocation methods are compared for impacts on farm income under three water supply scenarios. Results show that a (1) proportional sharing of water shortages among provinces and (2) unrestricted water trading rank as the top water allocation methods. The shadow price of water for irrigation rises from zero at a full water supply level to \$ US 93 per thousand cubic meters when supply falls to 20 percent of full levels. Results carry important implications for the design and efficient implementation of water rights systems in the world's irrigated regions.

Geographic Information System for Water Resources Research Planning

Basic Information

Title:	Geographic Information System for Water Resources Research Planning
Project Number:	2012NM139B
Start Date:	3/1/2012
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	NM02
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	None
Principal Investigators:	Susanna Heather Glaze

Publication

1. Olmstead, A., S. Walker, and C. Brown. 2013. Recipe for clean water: researchers create toolkit to pinpoint regions at high risk for groundwater contamination. Research + Resources.

Description of problem and research objectives

The New Mexico Water Resources Research Institute has become the focal point for geographic information system (GIS) data and information concerning water resources in New Mexico. It combines database management with digital mapping into spatial-tabular data models. These models are powerful tools for representing and manipulating earth-science information.

As use of geographic information systems has grown and presented new opportunities, it also has raised a number of new issues and problems. Of increasing concern is the management of a growing collection of spatial data sets and applications programs. These data sets and programs are very expensive to produce but relatively easy to share, so there is a great incentive to avoid duplicating production efforts. The trend clearly is toward managing these elements in distributed spatial libraries.

The primary objective of the project is to increase availability and accessibility of water resource information to support water resource planning and management in the state. The first task provides spatial data library accessibility. This task maintains arrangements and establishes those necessary to provide access to spatial data maintained by other agencies and organizations. The second task, spatial data development, evaluates needs, establishes priorities, and undertakes development of spatial data that is otherwise unavailable. These efforts will be coordinated with cooperating agencies and organizations to ensure no duplication of effort and to establish guidelines for coverages and priorities. The principal investigators maintain, update as necessary, and make the data available to cooperating agencies and organizations through both formal and informal arrangements to facilitate water resource planning activities.

Description of methodology

A number of cooperative data sharing agreements have been entered into with state, federal, and local agencies and organizations to facilitate access and to develop spatial data. Others will be pursued as necessary. Research funded by the NMWRRI in many cases results in the development of data that can be represented in a spatial form and thus can contribute to the state data pool. Projects that have such a potential are adjusted as necessary to meet this secondary purpose.

The NMWRRI maintains a GIS laboratory consisting of computer workstations; data storage devices; input/output devices; software for mapping and analysis (ARC/Info); database development and visualization; and network systems. The laboratory is connected via fiber to the New Mexico State University computer network and thereby to the Internet. The NMWRRI also maintains an Internet web server site through which both spatial and tabular water resource data can be provided.

Description of principal findings and significance

Various research activities are supported by the system for water resources planning in the state. The New Mexico Interstate Stream Commission has utilized GIS mapping products for use in

their regional plans and in public outreach. Additionally, support has been given to the New Mexico/Texas Water Commission and various public entities of southern New Mexico for their planning activities. GIS mapping support is also provided to the Lower Rio Grande Water Users Organization.

The GIS sophisticated mapping and geo-spatial database management system, originally designed to support WRRI-funded research activities, has been used for external research grants (e.g., Creation of a Digital Hydrogeologic Framework Model of the Mesilla Basin and Southern Jornada del Muerto Basin; creation of maps for the purpose of water planning funded by the New Mexico Interstate Stream Commission; and pesticide management planning in the state funded by the New Mexico Department of Agriculture) by water resources management and planning agencies in the state. A research grant resulted in the creation of a regional geographic information system to support water planning in the Paso del Norte borderland area of the southwestern United States.

During the reporting period, projects funded through the GIS lab were sponsored by USGS, Southwest Consortium for Environmental Research & Policy, the Border Environment Corporation Commission, and the National Park Service.

This is an ongoing project with new data continually being added to the database and assistance being given to produce specific GIS products upon request. Continued funding is anticipated from annual state appropriations as well as pending agency awards.

Updating the Digital Hydrogeologic-Framework Model of the Mesilla Basin Area with Specific Reference to the Transboundary Aquifer Assessment Project (TAAP)

Basic Information

Title:	Updating the Digital Hydrogeologic-Framework Model of the Mesilla Basin Area with Specific Reference to the Transboundary Aquifer Assessment Project (TAAP)
Project Number:	2012NM141B
Start Date:	3/1/2012
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	NM02
Research Category:	Ground-water Flow and Transport
Focus Category:	None, None, None
Descriptors:	None
Principal Investigators:	John W Hawley

Publications

1. Monger, H.C., Buck, B.J., Hawley, J.W., and Rachal, D., 2012, Geochronology of the Bolson sand sheet, New Mexico and Texas, and its archaeological significance: Discussion: Geological Society of America Bulletin; 124:9/10:1552-1556, 3 figures; doi: 10.1130/B30517.1
2. Hawley, J.W., and Granados-Olivas, A., 2012, Progress report on development of an annotated bibliography for transboundary aquifer systems of the Mesilla Basin-Paso del Norte area, New Mexico, Texas, and Chihuahua, in Aquifers of West Texas-Theme Session T5: Geological Society of America, Abstracts with Programs, 44:1:38., No.199147 on CD-ROM.
3. Hawley, J.W., Kennedy, J.F., and Granados-Olivas, A., 2012, Hydrogeologic framework of transboundary aquifer systems in the Paso del Norte region--Texas, New Mexico, and Chihuahua, in Aquifers of West Texas-Theme Session T5: Geological Society of America, South-Central Section, Abstracts with Programs, 44:1:32., No. 199140 on CD-ROM.
4. Hawley, J.W., Kennedy, J.F., and Ortiz, M.A., 2012, The Tularosa Basin and Hueco Bolson transition zone: A linked hydrogeologic system in south-central New Mexico, USA, in Hydrogeology of the Sierra Blanca, Sacramento Mountains, and Tularosa Basin, New Mexico-Theme Session T6: Geological Society of America, Abstracts with Programs, 44:6:No. 203247 on CD-ROM.

Description of problem and research objectives

The arid-semiarid Mesilla Basin area of the south-central New Mexico border region includes major irrigation-agriculture projects in the Rio Grande Valley, and two large metropolitan centers: Las Cruces (NM) and the binational El Paso/Ciudad Juárez area, the latter with a population of about two million. Ever expanding municipal-industrial (M&I) water-supply requirements are now partly met by Elephant Butte Project surface-flow diversions, which are still primarily used for agriculture. Groundwater of varying quality in the large, but still-finite basin-fill aquifer systems of the region remains the primary water source for M&I uses; and in times of surface-water shortages, available subsurface-water resources are increasingly being exploited as a supplemental source for irrigation agriculture. Projected shortages in upstream river-basin source areas, reflecting both natural and anthropogenic environmental changes, only serve to exacerbate the long-term water-supply problems that face New Mexico's Lower Rio Grande region. Continued work on the hydrogeology of basin-fill aquifer systems of the Mesilla Basin area are therefore especially relevant, simply because it provides the state-of-the-art baseline information needed for development of the geohydrologic and hydrochemical models, which are in turn are required for equitable resolution of ongoing and future water-resource management disputes.

This study's primary research objective is to provide digital hydrogeologic information on basin-fill aquifer systems of the Mesilla Basin area in GIS formats (primarily ArcGIS) at scales appropriate for development of *basin-scale* groundwater-flow and hydrochemical models (~1:100,000). The hydrogeologic framework of these extensive and thick intermontane-basin fills has now been characterized in a large area between Caballo Dam and El Paso del Norte/Ciudad Juárez that includes the Mesilla Basin (USA and Mexico), the Mesilla and Rincon Valleys of the Rio Grande, and contiguous parts of the southern Jornada (del Muerto) and Palomas Basins (NMWRRRI Technical Completion Report [TCR] 332, Hawley and Kennedy, 2004-05). However, complete digitation of 3-D hydrogeologic map and cross-section components started in 2007 by NMWRRRI as part of the interagency Transboundary Aquifer Assessment Act (PL 109-448) Project (TAAP) was significantly curtailed in early 2010 following the untimely death of the original Project PI, Dr. Bobby J. Creel and unforeseen cutbacks in NMWRRRI program support.

The above-described events notwithstanding, Co-PI John W. Hawley (JWH) made substantial progress in hydrogeologic-framework characterization during the Phase 2 TAAP work completed in March 2011. Primary products included final hard-copy drafts of 1) four structure-contour maps (1:100,000 scale) of the model-boundary surfaces that define basal, middle, upper, and shallow parts of the basin-fill aquifer system; and 2) twenty-three hydrogeologic cross sections (sea-level base) that illustrate aquifer-system lithology, hydrostratigraphy and structure in the intermontane-basin and river-valley area between Caballo Dam and El Paso/Ciudad Juárez. However, digital formatting of these items, final editing of the study area's hydrogeologic base map, and compilation of the map and cross-sections into a 3-D hydrogeologic-framework portrayal remained uncompleted in 2011. Therefore 104b-Project funding was requested in early 2012 to

complete the hydrogeologic-framework characterization required for numerical modeling of groundwater flow and hydrochemistry in aquifer systems of the TAAP study area.

Description of methodology

According to the methodology outlined in the original (1/14/2012) 104b funding proposal, specific items that needed to be scanned and digitized, “after final editing,” at the NMWRRI GIS Laboratory include:

a. Drafts of new structure-contour maps of major hydrostratigraphic-unit (HSU) surfaces in the part of the study area between the lower Rincon Valley and El Paso del Norte. These maps illustrate best-available interpretations of subsurface topography and significant geologic features (e.g., faults) of the four bounding surfaces that separate the primary HSU components of the basin-fill aquifer system as well as derivative groundwater flow-model layers: 1) basal contact of basin and/or valley fill (Santa Fe Group and/or river-valley alluvium) on underlying and basin-border bedrock units; 2) Middle/Lower Santa Fe HSU boundary surface; 3) Upper/Middle Santa Fe HSU boundary surface; and 4) base of an inferred “shallow-aquifer” system, which includes a) river-valley fill, and b) the upper 300 to 500 ft of hydrologically linked Santa Fe Group HSUs in the east-central and southeastern Mesilla basin area. Provisional hydrogeologic interpretations are also shown in the Mesilla Basin area south of the International Boundary that includes the new Conejos-Médanos Basin well field.

b. Drafts of 23 hydrogeologic cross sections (MSL base elevation, 10x-vertical exaggeration) for the Rio Grande Valley and adjacent basin areas between Caballo Dam and El Paso del Norte. Digital versions of most of these sections (Adobe Illustrator format) were originally created for NMWRRI-TCR 332 (2004-05); but subsequent editing (2007-11) showed that the 10-m DEM originally used in surface-profile construction could not provide needed precision in areas of low topographic relief, and some profiles had to be manually redrawn using more-detailed elevation control. In addition, minor well-location errors had to be corrected; and some revisions were needed to insure that the combined x-section and structure-contour-map formats are geometrically consistent.

c. During the 3/1/2012 to 2/28/2013 “Project Period,” the critical “final editing” phase of the hydrogeologic base map (ArcGIS product) in collaboration with Ms. Heather Glaze, NMWRRI GIS Coordinator, proved much more time-consuming than originally envisioned. It also was soon determined that scanning and digitation of the four structure-contour maps (7a) would be most efficiently accomplished by using student-assistance at the GIS-lab facilities of the USGS-Albuquerque Office rather than at the WRRI. This enabled the PI (JWH) to actively participate in the process of map compilation and editing without extended trips to Las Cruces. With respect to updating and editing the hydrogeologic sections (7b), most of which were already digitized in Adobe Illustrator (AI) format, both the NMWRRI and USGS lacked staff with experience with AI software and/or AI-ArcGIS integration during this “Project Period.” In this situation, the additional

sections (4) and several section-extensions needed to fill gaps in 3-D coverage were scanned in pdf/jpg formats to facilitate future conversion to AI/ArcGIS products.

d. Continued updating of Excel spreadsheets that summarize basic information on now about 500 *key wells* in the basin and river-valley area south of Caballo Reservoir (465 in NM, 25 in TX, and 10 in Chihuahua). This database supports interpretations used in development of the above-described hydrogeologic maps and cross sections, and includes hydrostratigraphic-unit and potentiometric-surface elevations, and reference citations. The annotated bibliography on a broad range of topics related to aquifer systems of the Transboundary region, which started being compiled in TAAP Phase I, is being expanded on an ongoing basis (*see Part 9: Hawley and Granados-Olivas, 2012*).

Principal findings and significance.

Project work completed:

(1) A new digital base map (1:100,000) of the entire study area has been compiled (i.e., Mesilla Basin, and parts of the Jornada del Muerto and Palomas-Rincon Basins between Caballo Reservoir and El Paso del Norte). It includes the basic hydrogeologic elements (hydrostratigraphic, lithofacies, and structural) required for basin-scale groundwater-flow and hydrochemical model development. The ArcGIS format facilitates a) mapping of significant geohydrologic-boundary conditions (surface and subsurface), b) integration with four structure-contour maps of model-layer interfaces (subsurface), and c) preparation of schematic hydrogeologic sections that illustrate 3-D distribution of hydrostratigraphic and lithofacies units. At present, however, the only map area prepared for NMWRRRI publication comprises the Mesilla Basin and adjacent parts of the southern Jornada Basin and Rincon Valley that have at least some hydrologic connection with Trans-International Boundary aquifer systems. A simplified version of the hydrogeologic map is used primarily as an index map for cross-section and key-well locations, and shows only major classes of basin-fill deposits, bedrock units, and fault types.

(2) Four new structure-contour maps of major hydrostratigraphic-unit (HSU) surfaces in the study area between the lower Rincon Valley and El Paso del Norte have been digitized and are in final stages of editing in collaboration with the USGS-Albuquerque Office, Hydrologic and GIS staff (7a). These maps illustrate best-available interpretations of subsurface topography and significant geologic features (e.g., faults) of subjacent bedrock units, and the bounding surfaces that separate the primary hydrostratigraphic (HSU) components of the basin-fill and (river) valley-fill aquifer systems. They are designed specifically to provide a robust geohydrologic framework for definition of groundwater-flow-model layer boundaries.

(3) A grid of twenty-seven hydrogeologic sections has now been completed that covers the entire study area between the Caballo Reservoir part of the central Palomas Basin and the southernmost Mesilla (northern Conejos-Médanos) Basin-El Paso del Norte in Chihuahua and western Texas (7b); and they complement the above-described structure-contour maps (7a, 8a (2)). These cross sections schematically illustrate the best-available interpretations of subsurface topography and significant geologic features (e.g., faults and

lithofacies distribution) of the bounding surfaces that separate major hydrostratigraphic (HSU) mapping units of the basin-fill and valley-fill aquifer systems. Their most important geohydrologic function is to provide a robust framework for defining the internal composition of layers that form the basic components of groundwater-flow and hydrochemical models. As already noted (7c), preparation of the set of 27 cross sections in a GIS format suitable for publication has not been completed (See 8b).

Project work remaining:

With respect to updating and final editing the hydrogeologic sections (7b, 8a (3)), both the NMWRRRI and USGS still lack staff with user experience involving AI software and/or AI-ArcGIS integration during the remainder of the present (3/1 to 6/30/2013) “Project Period.” Because of this, original sections published in NMWRRRI TCR 332 (2004-05) continue to be utilized; and additional sections (4) and several section-extensions needed to fill gaps in 3-D coverage have been scanned in pdf/jpg formats to facilitate future conversion to AI/ArcGIS products. To be able to complete this remaining task the PI (JWH) is now (5/2013) formally authorized as a USGS volunteer to have access to their Albuquerque Water Science Center GIS lab and ESRI-licensed software. This will greatly facilitate final editing of the digitized structure-contour maps.

The major remaining task involves final digital compilation of the 27 hydrogeologic sections in appropriate Adobe Illustrator format and then integrating them with the ArcGIS hydrogeologic base map and four structure-contour maps. The USGS-Albuquerque Office has all the licensed software to do the work, but qualified personnel are currently not available. To help resolve this problem the PI has obtained the temporary services of a recent NMED retiree, geologist Baird Swanson, who is also a USGS volunteer and has requisite AI and ArcGIS skills to assist in completing this particular task. To date, this has been a strictly *pro bono* effort; but application is being made to the NMWRRRI for a short-term contract that will cover the bulk of the expenses that Mr. Swanson incurs in this component of unfinished “Project Work.”

Preparation of a Project Completion Report (PCR) on the current status of digital-baseline hydrogeologic information on the Mesilla Basin area, including contiguous parts of the Jornada Basin and connecting valley reaches of the Rio Grande that are located between the southern Rincon Valley and Paso del Norte. Emphasis will be on research aspects with direct bearing on groundwater-flow and hydrochemical model development.

Information Transfer Program Introduction

The New Mexico Water Resources Research Institute maintains an active program to transfer technical information from the producer to the user and the public. Technical publications, newsletters, conferences, symposia, press announcements, and presentations keep practitioners aware of new technology and research advances. The WRII homepage (wrii.nmsu.edu) provides online information about the institute's newsletters, technical report series, requests for proposals, upcoming conferences and symposia, and the research reference library. All 57 past annual water conference proceedings have full-text viewing via the institute's homepage. Other federal and state servers, such as the U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, USGS, Bureau of Reclamation, and National Weather Service are linked to the WRII homepage.

Information Transfer Program

Basic Information

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Statement of Critical Water Problem

The New Mexico Water Resources Research Institute's Information Transfer Program is designed to bring the results of its research projects to the public and to educate New Mexicans on the critical water issues of the state, region, and nation. Different sectors of the public are targeted for each of its activities.

Statement of Results and Benefits

The program goal is to provide people with water information appropriate to their level of training and interest. Information transfer activities are funded primarily from non-federal sources. Responsibilities for different segments of the program have been assigned to various professional and support staff at the institute.

Nature, Scope, and Objectives

The primary methods for information transfer are conferences, publications, audio/visual presentations, and information posted on the institute's website. For the past 57 years, the NMWRRI has sponsored the Annual New Mexico Water Conference focusing on a topic of importance to the New Mexico water community, usually policy oriented. The annual conference is held in different locations around the state in the fall. Most of the conference participants are water resources practitioners working for state, federal, or local agencies, although some members of the general public and of academia also attend. Average attendance ranges between 150 and 200 people, depending on the location and topic of the conference. However, the 2012 conference had an attendance of over 500. A few years ago, the New Mexico State Engineer called the NMWRRI annual conference the premier water meeting in the state. The NMWRRI began hosting a technical research symposium in 2002 and the annual event has become the focal meeting for researchers from around the state and region to share their water-related research and demonstration projects. Due to budget restrictions, for the past two years the technical symposium has been combined with the annual water conference. Many students present posters at the technical symposium or water conference.

Publications include technical completion reports resulting from NMWRRI-sponsored projects, special in-house publications, and conference proceedings. The institute has published more than 386 technical and miscellaneous reports. The peer reviewed technical completion reports are directed toward water professionals working in disciplines related to the research projects. All technical reports are now available via the NMWRRI website in full text. Those interested in a particular report are able to print off the Internet instead of ordering a hard copy of the report. NMWRRI water conference proceedings for the past 57 years are also available online in full text.

An institute's newsletter, *The Divining Rod*, focuses on research and current water issues. It is emailed to approximately 1,600 readers and hard copies are sent to about 200 readers. The newsletter is available on the NMWRRI homepage.

A reference room, housed at the institute, contains over 11,000 documents and is used by faculty, students, and the general public. A complete catalog of holdings can be searched through the NMWRRI homepage on the Internet, along with an extensive water resources and information system database.

NMWRRI's homepage (<http://wrri.nmsu.edu>) provides online information about the institute's newsletters, technical report series, requests for proposals, upcoming programs, and the research reference library. All NMWRRI reports are available for viewing online via the institute's website. The website, created in 1995, is updated on a regular basis and continues to be a focal point of information on New Mexico's water resources with many links to other related sites such as the U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, USGS, Bureau of Reclamation and National Weather Service. In recent years, the NMWRRI website received an average of over 6,000 inquiries per month.

NMWRRI has developed a state-of-the-art geographic information system on water resources in New Mexico and has become the focal point for GIS data and information concerning water resources in the state. It combines database management with digital mapping into spatial-tabular data models. These models are powerful tools for representing and manipulating earth-science information. The primary objective of the system is to increase availability and accessibility of water resource information to support water resource planning and management in the state. Efforts are coordinated with cooperating agencies and organizations to ensure no duplication of effort and to establish guidelines for map coverages and priorities. The staff maintains, updates as necessary, and makes the data available to cooperating agencies and organizations through both formal and informal arrangements to facilitate water resource planning activities. In recent years, the NM WRRI has provided GIS expertise on a regular basis to the National Park Service.

The institute director is invited frequently to speak at local, regional, and national conferences and workshops in addition to serving on a number of committees that focus on water resources.

Accomplishments

The 57th Annual New Mexico Water Conference was held on the New Mexico State University (NMSU) campus in Las Cruces, New Mexico and was co-hosted by New Mexico Senator Tom Udall and NMSU. The conference theme was, "Hard Choices: Adapting Policy and Management to Water Scarcity" and was attended by over 500 participants (including over 50 students), a record for the institute's annual conference. The conference was also webcast across the state for the first time. It brought together farmers, ranchers, engineers, experts and community members to address the impact of water scarcity and explore possible solutions to help New Mexico adapt to the ongoing drought. A one-day workshop was held following the conference where water experts representing diverse interests met to recommend actions developed from the conference. The 31-page conference report was prepared and contains 40 proposed actions. The report is available on Senator Udall's website and on the NM WRRI website. The conference proceedings will be available NM WRRI's website. All conference participants will receive a copy on CD.

Again this year, the annual technical symposium was combined with the annual water conference. Thirty posters were presented, many by students. The conference provided a unique opportunity

for researchers and students to network with other water stakeholders including policy makers. The conference received sponsorship from Sandia National Laboratories, Los Alamos National Laboratory, New Mexico State University, Elephant Butte Irrigation District, Rio Grande Basin Initiative, the Hazel and Ulysses McElyea Endowment, and Senator Tom Udall.

The institute's publications for the period included a book, part of the New Mexico Centennial History Series, which contains 16 chapters on the many complex legal and otherwise fights over water in New Mexico. The book entitled, "One Hundred Years of Water Wars in New Mexico 1912-2012" has received positive reviews including: "This book describes in considerable detail how we've arrived at our present water status and focuses more on the history, management decisions and consequences than other recent books.... It should be required reading of all water professionals practicing in NM." The 57th Annual New Mexico Water Conference proceedings is in being produced in hardcopy and on CD. It will also be posted on the institute's website as are all publications.

The institute's website averages over 10,360 unique online visits each month. It averages nearly 2,900 online unique visits for publications from its technical and miscellaneous report series and an average of about 13,000 unique visits and pdf downloads per month of its proceedings series. Because of the ability to view and print all institute publications online, the WRRI is averaging only a few requests for hard copies of specific publications each month via postal mail or visits to the institute. Requests online have continued to increase each year.

The institute's newsletter, *The Divining Rod*, is an eight- to sixteen-page newsletter that focuses on research projects administered by the NMWRRI and on current water issues in New Mexico. It provides information on upcoming conferences, seminars, and workshops; describes new grants and newly released publications; and provides general information on new developments in water resources research and management. Each issue is available on the NMWRRI's homepage. Hard copies of the newsletter are distributed to approximately 200 readers and about 1,600 readers receive it via email with a pdf of the newsletter attached. To become more cost-effective and to save resources, the institute is now distributing the newsletter primarily via email. During the reporting period, the institute published three newsletters, one 8-page issue, one 12-page issue and a 16-page issue of *The Divining Rod*. The newsletter received an average of 344 downloads per month online during the past year. Online unique visits per month of the WRRI's reference room averaged about 205 for the reporting period.

The institute's director participates in local, state, and national conferences and workshops and speaks before many groups. He is an active member of the National Institutes for Water Resources and is the chair of the NIWR-USGS Partnership Committee. Also a member of the Universities Council on Water Resources, he helped plan the 2012 national meeting held in Santa Fe, New Mexico. The NMWRRI staff also regularly provides expertise for solving specific problems and general concerns. They play a central role in planning for the water future of the region by cooperating with a host of water resources entities throughout the state and region, particularly in the Paso del Norte area. This past year, the institute served a central role in several water-related initiatives proposed to the 2013 New Mexico legislative session.

The Information Transfer Program is an ongoing program with no particular timelines.

USGS Summer Intern Program

None.

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	2	0	0	5	7
Masters	1	0	0	3	4
Ph.D.	1	0	0	1	2
Post-Doc.	0	0	0	0	0
Total	4	0	0	9	13

Notable Awards and Achievements

NMWRRI nominated New Mexico Tech researcher, Dr. John L. Wilson for this year's NIWR Impact Awards. Dr. Wilson received a 12-month USGS 104B award (2011-2012) for his project entitled, "Computational Fluid Dynamics Modeling of Karst Conduit-Matrix Exchanges with Relevance to Contaminant Transport and Chemical Reactions." Dr. John Wilson is an internationally recognized hydrologist. Since 1987, he has received funding through the NM WRRI for various projects that study contaminant flow and groundwater quality. He is the recipient of numerous awards throughout his career including the New Mexico Eminent Scholar, Darcy Lectureship, O.E. Meinzer Award in Hydrogeology, and American Geophysical Union Hydrologic Science Award as well as an elected fellow of the Geological Society of America and the American Geophysical Union. Professor Wilson has supervised more than 50 students over the years, many of whom are now established university faculty and federal laboratory scientists. He and his students have also published extensively on studies of the movement of water, non-aqueous phase liquids, dissolved chemicals, colloids, and bacteria through porous, fractured, and faulted media.

Material from the Transboundary Aquifer Assessment Program (TAAP), a special USGS award, was included in a two-week Interdisciplinary Modeling Course at New Mexico State University in 2012.

New Mexico State University initiated a new interdisciplinary Water Science and Management graduate degree program. Three new PhD classes have been added to the Department of Agricultural Economics/Agricultural Business to support the new program and will be taught for the first time in the academic year 2013-14. Classes will also be added to the Department of Civil Engineering and the Department of Geography.

Graduate student and GIS program technician Steve Walker received third place for his poster presentation, "Examining aquifer pollution sensitivity in the Central Paso del Norte region using the DRASTIC model" at the Annual Meeting of the Southwest Division of the Association of American Geographers (October 2012, Las Cruces, NM). The poster was co-authored by GIS colleagues Heather Glaze and John Hawley. The New Mexico State University News Center published an article on the conference highlighting Walker's work. The article was also carried by the local newspaper, Las Cruces Bulletin on November 23, 2012.

James Witcher, geothermal energy consultant and formerly with New Mexico State University, was inducted into NMSU's Geology Hall of Fame in 2012. In 2009, Jim was honored as the preeminent researcher on geothermal energy in New Mexico by the New Mexico Energy, Minerals, and Natural Resources Department. Having graduated with a BS in 1977 and an MS in 1993 from NMSU, Jim has had a long association with the NM WRRI. He is the first author of a 2004 NM WRRI technical report entitled, "Sources of Salinity in the Rio Grande and Mesilla Basin Groundwater" and presented a talk at NM WRRI's 2011 annual water conference, "Geothermal Resources Suitability for Desalination in New Mexico."

Publications from Prior Years

1. 2006NM44B ("Development of Geospatial Modeling Tools for Watershed-based Water Resources Management in New Mexico (Vivoni)") - Articles in Refereed Scientific Journals - Gutiérrez-Jurado, H.A. and Vivoni, E.R. 2013. Ecogeomorphic Expressions of an Aspect-controlled Semiarid Basin: I. Topographic Analyses with High Resolution Data Sets. *Ecohydrology*. 6:1:8-23.
2. 2006NM44B ("Development of Geospatial Modeling Tools for Watershed-based Water Resources Management in New Mexico (Vivoni)") - Articles in Refereed Scientific Journals - Gutiérrez-Jurado, H.A. and Vivoni, E.R. 2013. Ecogeomorphic Expressions of an Aspect-controlled Semiarid Basin: II. Topographic and Vegetation Controls on Solar Irradiance. *Ecohydrology*. 6:1:24-37.
3. 2006NM44B ("Development of Geospatial Modeling Tools for Watershed-based Water Resources Management in New Mexico (Vivoni)") - Articles in Refereed Scientific Journals - Moreno, H.A., Vivoni, E.R., and Gochis, D.J. 2013. Addressing Uncertainty in Reflectivity-Rainfall Relations in Mountain Watersheds during Summer Convection. *Hydrological Processes*. (In Press).
4. 2006NM44B ("Development of Geospatial Modeling Tools for Watershed-based Water Resources Management in New Mexico (Vivoni)") - Articles in Refereed Scientific Journals - Moreno, H.A., Vivoni, E.R., and Gochis, D.J. 2013. Limits to Flood Forecasting in the Colorado Front Range for Two Summer Convection Periods using Radar Nowcasting and a Distributed Hydrologic Model. *Journal of Hydrometeorology*. (In Press).
5. 2006NM44B ("Development of Geospatial Modeling Tools for Watershed-based Water Resources Management in New Mexico (Vivoni)") - Articles in Refereed Scientific Journals - Vivoni, E.R. 2012. Spatial Patterns, Processes and Predictions in Ecohydrology: Integrating Technologies to Meet the Challenge. *Ecohydrology*. 5:3:235-241.
6. 2006NM44B ("Development of Geospatial Modeling Tools for Watershed-based Water Resources Management in New Mexico (Vivoni)") - Articles in Refereed Scientific Journals - Vivoni, E.R. 2012. Diagnosing Seasonal Vegetation Impacts on Evapotranspiration and its Partitioning at the Catchment Scale during SMEX04-NAME. *Journal of Hydrometeorology*. 13:1631-1638.
7. 2009NM103B ("Land application of industrial effluent on a Chihuahuan Desert ecosystem: Impact on soil physical and hydraulic properties") - Articles in Refereed Scientific Journals - Deb S.K., M.K. Shukla, P. Sharma, and J.G. Mexal. 2013. Patterns of soil water depletion in irrigated mature pecans of arid southern New Mexico. *Irrigation Science*. 31:69-85.
8. 2009NM103B ("Land application of industrial effluent on a Chihuahuan Desert ecosystem: Impact on soil physical and hydraulic properties") - Articles in Refereed Scientific Journals - Deb, S. K., M. K. Shukla, and J. G. Mexal. 2012. Simulating deep percolation in flood-irrigated mature orchards with RZWQM2. *Transactions of the ASABE*. 55:6:2089-2100.
9. 2006NM50B ("Estimating Water Use through Satellite Remote Sensing (Bleiweiss)") - Articles in Refereed Scientific Journals - Elsadek A., M.K. Shukla, M. Bleiweiss, S. Fernald and S. Guldan. 2013. Evaluating sensitivity analysis and auto-calibration of a semi-distributed hydrological model for two semiarid watersheds of New Mexico. *New Mexico Journal of Science*. 46:65-88.
10. 2009NM103B ("Land application of industrial effluent on a Chihuahuan Desert ecosystem: Impact on soil physical and hydraulic properties") - Other Publications - Ochoa, C., S. Fernald, S. Guldan, M. K. Shukla and V. C. Tidwell. 2012. Deep percolation and water table fluctuations in response to irrigation inputs: field observation. *New Mexico Journal of Science*. 46: 89-104.