NM EPSCoR RII3: Climate Change Impacts on New Mexico's Mountain Sources of Water

Strategic Plan

Climate change is affecting natural environments around the world. NM EPSCoR RII3 addresses a key challenge that is of worldwide significance—understanding and forecasting the effects of climate change on water supply and sources in arid regions, as well as the socioeconomic implications. The overarching **vision** for the NM EPSCoR Program is to enable:

"An environment in which New Mexico scientists and educators are fully competitive in climate change research and education."

NM EPSCoR RII3 is designed to enhance research competitiveness through investment in three strategic areas: *(1) critical Research Infrastructure, (2) Cyberinfrastructure, and (3) Human Infrastructure.* These investments will help establish NM as a laboratory for climate change research, and as a model for science-based public policy. The multi-disciplinary, multi-scale effort is envisioned to transform climate change science and policymaking in NM by providing the tools required for quantitative, science-driven discussion of difficult water policy options facing the State in the 21st Century. These goals are articulated in the NM EPSCoR **mission**:

"Provide the critical gap infrastructure, computational support, and education and outreach opportunities to foster excellence in climate change research and education."

Proposed research infrastructure investments support development of watershed-scale observational databases and coupled atmosphere-land surface-hydrology models needed in NM for water supply forecasting and water resources decision support. RII3 also supports research on the socioeconomic impacts of basin-scale hydrologic changes to *acequias* - the traditional water supply system for agriculture in small communities that has been an integral cultural feature of NM for centuries. New cyberinfrastructure investments will facilitate the rapid delivery of climate change data and information to scientists, educators, decision-makers, and the public. Proposed investments in outreach and communication will create an informed citizenry that is aware of climate change impacts on natural resources. In addition, education and diversity investments are closely integrated to increase impact on the critical student population at NM's non-PhD granting institutions. Innovative elements of the outreach, education and diversity programs reach a large and diverse population in both rural and urban areas, with an emphasis on involving and supporting the State's 'majority minority' population of Native Americans and persons of Hispanic descent.

Through novel projects and partnerships that are facilitated by NM EPSCoR Research Infrastructure Improvements, scientists and educators will contribute to serving the needs of science, education, and the public. In order to achieve the broadest impact, New Mexico RII3 participants have strategically defined the scope of what we do, the stakeholders we serve, and how we intend to achieve our mission. In the remainder of this document, we focus on 14 specific strategic objectives and the key actions that will enable us to achieve these objectives. The objectives are grouped by major focal area for the investment: (1) research infrastructure; (2) cyberinfrastructure; and (3) human infrastructure. An accompanying ***Implementation Plan*** provides details with respect to the activities supported, participants, planned actions, deliverables and milestones, resources, efforts to promote sustainability, and any changes that are envisioned for implementation since the original proposal was submitted.

Strategic Objectives

Research Infrastructure Improvements

Objective 1: Enhance climate and hydrology research infrastructure (from data acquisition through modeling).
Actions

- Significantly upgrade climate and hydrology observing networks in northern New Mexico.
- Map snowfall utilizing historic and current satellite data.
- Support development of coupled atmosphere-land surface process models.
- Apply and improve existing models for snowmelt runoff, surface water-groundwater interactions, and basin-wide partitioning of water resources for urban, agricultural and other uses.

Objective 2: Improve water quality monitoring in high altitude stream environments.

Actions

- Develop new and apply existing water quality sensors for the autonomous monitoring of stream waters in high altitude environments.
- Deploy a set of state-of-the-art, near-real-time, autonomous water quality sensors for monitoring the quality of surface water in at least two watersheds in New Mexico that are fed by snowmelt.
- Use data from co-located hydrology sensors and the water quality sensors to understand the controls on water quality in each watershed.
- Develop a diverse group of interdisciplinary and multi-institution collaborators, facilities, and educational efforts within New Mexico concerned with understanding stream water chemistry dynamics.

Objective 3: Develop interdisciplinary socioeconomics and acequia research capacity.

Actions

- Install new *in situ* infrastructure and use high-resolution satellite data and simulation models to characterize acequia system flow distribution and surface-groundwater hydrological interactions.
- Document the ancient customs and traditions of acequia systems during times of climate variability.
- Develop and use data and simulation models to improve the understanding and management of water in New Mexico's agro-environmental systems.
- Significantly increase overall system dynamics economic-behavioral-physical modeling capabilities via development of a collaborative interdisciplinary team and through expansion of modeling tools.

Objective 4: Provide critical gap infrastructure for New Mexico Highlands University.

Actions

- Upgrade the aquatic chemistry laboratory at NMHU for state-of-the-art water quality analysis that enhances the ability to perform research on climate change and water resources.
- Provide training in the use of the instrumentation for graduate and undergraduate students.
- Incorporate use of instruments in course curricula.

Objective 5: Use Innovation Working Groups (IWG) to address key scientific, education, diversity, and workforce development challenges.

Actions

- Support IWGs that address challenges in the climatological, hydrological, and socioeconomic sciences, as well as education, communication and outreach, and diversity.
- Support an interdisciplinary IWG entitled "Bridging Disciplines and Bridging Scales" that will focus on how to build connections across disciplines (e.g. climate change, surface hydrology, economic modeling) and how to bridge the tremendous gaps in spatial and temporal scales (e.g. from global climate change to economic impacts in NM).
- Support Tri-State NSF EPSCoR IWGs for Nevada, NM and Idaho that will promote regional and inter-jurisdictional collaborations.

Objective 6: Provide Critical Infrastructure Gap Seed Awards to increase the impact of NM EPSCoR on the critical student population at New Mexico's non-PhD granting institutions.

Actions

- Provide seed awards to the regional universities and tribal colleges.
- Support purchase of research and teaching equipment related to climate change, hydrology and water quality.
- Provide funding for student researcher salaries, research supplies, and student conference travel.
- Integrate proposed activities with the Undergraduate Research Opportunities Program.

Cyberinfrastructure Improvements

Objective 7: Enhance scientific data and model output generation, management, discovery, and use through cyberinfrastructure.

Actions

- Develop efficient data acquisition, processing, and storage models that enable streamlined management of data products acquired and generated by the project.

- Develop a model for the effective use of high performance computing.
- Support interoperable data discovery and delivery.
- Deploy collaboration tools that facilitate knowledge exchange.
- Develop a portal that provides a single point of access for project products, services, and information.

Human Infrastructure Improvements

Objective 8: Enhance diversity in all elements of the EPSCoR Program.
Activities
- Increase the research capacity of non-PhD granting institutions (focusing on underrepresented groups).
- Increase and improve the quality of STEM education in K-12 schools in rural areas and on tribal lands.
- Support diversity training for teachers and university/college faculty.
- Increase the number of incoming students into STEM disciplines from underrepresented groups.
- Utilize one IWG per year to monitor diversity goals and advise programs on diversity issues.

Objective 9: Enhance professional teacher development for STEM areas in northern New Mexico.
Actions
- Support teams of middle school teachers that will participate in a three-day Summer Institute and weekend workshops where they will be engaged in scientific research and best pedagogy practices.
- Provide hands-on classroom science materials to teachers.
- Provide additional mentoring and support during the school year.

Objective 10: Develop an Undergraduate Research Opportunity Program that increases the exposure of students at non-PhD granting institutions to high quality, relevant, hypothesis-driven research.
Actions
- Engage undergraduates, recruited from institutions serving large populations of Hispanic and Native American students, in four to nine weeks of summer research with faculty mentors.
- Develop and support an initial week of workshops and short courses on climate change, hydrology, and water quality, which will be taught by EPSCoR-supported faculty.
- Conclude the program with a statewide conference where students will present the results of their research to an audience of students, faculty, and research staff.

Objective 11: Design and develop graduate research training group opportunities.
Actions
- Design and develop a Climate Change Graduate Seminar Course that will include EPSCoR scientists and recognized experts from within and outside the state.
- Support a Graduate Summer School in Regional Modeling that will include extensive hands-on training in running relevant climate, hydrologic, and socioeconomic models.

Objective 12: Inform faculty about funding opportunities via NSF Days.
Actions
- Develop and support NSF Days, a workshop, where NSF Program Directors will meet with faculty from colleges and universities to discuss relevant funding opportunities and strategies for seeking funding.

Objective 13: Enhance leadership skills for faculty via a Faculty Leadership Fellowship Program.
Actions
- Provide training for early-career faculty to enhance competitiveness and leadership skills.

Objective 14: Create a citizenry that is informed about climate change and its impact on NM's natural resources via public outreach and communication.
Actions
- Create a new Climate Change Exhibit at the New Mexico Museum of Natural History and Science.
- Develop a statewide Seminar Series.
- Provide community-based Science Cafés in northern New Mexico.
- Support a Town Hall that focuses on ways to promote economic development amidst climate change and uncertain water resource availability.

- Create a Climate Change Web Portal that provides easy public access to scientific information

NM EPSCoR RII 3: Climate Change Impacts on New Mexico's Sources of Water
Implementation Plan

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NM EPSCoR RII3: Implementation Plan

The implementation plan parallels the key improvement areas: Research Infrastructure, Cyberinfrastructure and Human Infrastructure. For each area, multiple activities are supported. The table below shows the implementation plan organization by improvement area and research focus activity. In addition, the table maps this document's organization to the original proposal.

Implementation Plan Infrastructure Improvement Area	Sections in Original Proposal
Research Infrastructure	
1. Climate and Hydrology Research **2. Water Quality** **3. Socioeconomics and Acequia Research** **4. Critical Gap Infrastructure for New Mexico Highlands University** **5. Innovative Working Groups** **6. Critical Gap Infrastructure Seed Awards**	· Proposal sections 4.4: · Monitoring and Analyzing Climate and Hydrology in Northern NM · In Situ Hydrologic Sensing Infrastructure · Multi-scale Multi-disciplinary Model Development · Innovative Working Groups · Infrastructure Seed Grant Programs
Cyberinfrastructure	
7. Cyberinfrastructure	· Proposal sections 4.5: · Data Acquisition, Processing and Storage · High Performance Computing · Interoperability · Collaboration Technologies · NM Climate Change Web Portal
Human Infrastructure	
8. Diversity **9. K-12 Professional Teacher Development** **10. Undergraduate Research Opportunity Program** **11. Graduate Research Training Group** **12. NSF Days** **13. Faculty Leadership Fellowship Program** **14. Public Outreach and Communication**	· Proposal sections 4.6 · Diversity Plan · Summer Institute for Teacher Professional Development · Undergraduate Research Opportunities · Climate Change Research Training Group · NSF Days · Junior Faculty Leadership Training · Outreach and Communication

For each infrastructure improvement area, a strategic objective is stated and followed by: activities supported, participants, specific actions and deliverables/milestones by year, resources, efforts to promote sustainability and additional information including changes of note.

Activity 1: Climate and Hydrology Research

Strategic Objective

The strategic objective is to promote close cooperation between hydrologists and climatologists at the various institutions in New Mexico that will yield a detailed understanding of climate change effects on water supply in the snowmelt and rainfall runoff basins in the Rio Grande Basin. At the same time, the project will support research training for graduate and undergraduate students engaged in climate and hydrological modeling. Specific objectives include a significant upgrading of climate and hydrology observing networks in northern New Mexico, development of coupled atmosphere-land surface process models, and application and improvement of existing models for snowmelt runoff, surface water-groundwater interactions, and basin-wide partitioning of water resources for urban, agricultural and other uses.

Activities Supported

- Support workshop collaborations among climatologists and hydrologists, along with joint climatology-hydrology workshops, to develop future climate and water resource scenarios for use by water management agencies in New Mexico. Economists will join the working groups to couple economic models to each climate/hydrology scenario.
- Workshop and working group collaborations will facilitate research infrastructure improvement activities at all three major research universities.

Supported activities at University of New Mexico (UNM) include:

- Assess fundamental processes controlling hydroclimatic change in model simulations and datasets.
- Apply climate change projections to the major sub basins of the Rio Grande including those selected for intensive study.
- Develop coupled atmospheric-surface processes models.

Supported activities at New Mexico State University (NMSU) include:

- Upgrading the climate and hydrology observing networks in New Mexico including precipitation and temperature stations, snow stations (SNOTEL), soil moisture stations, (SCAN), and flow stations on acequia networks. Additionally, remote sensing products will be added to the data base such as detailed land cover analysis from QuickBird and snow cover and NDVI from earth observation satellites.
- The Snowmelt Runoff Model (SRM) will be established on each of the 25 important snowmelt sub basins in the Rio Grande drainage in order to provide simulated and forecast flows as well as hydrologic scenarios in response to future climate scenarios.
- The Semi-distributed Land Use and Runoff Process (SLURP) model will be established on the entire Rio Grande basin to be used to assess the basin-wide consequences of climate change on the competing uses of water including agriculture, urban supplies, recreation, endangered species, and power. SLURP will also be linked to SRM for detailed snowmelt runoff inputs.
- Characterize the hydrological interactions between surface water and ground water flow in two different acequia systems that serve as tributaries to the Rio Grande. Determine whether acequias may play a central role in the interactions between surface water and groundwater that modulate and change the timing of the transmission of hillslope runoff to streamflow. (This research is further developed by the "Socioeconomics and Acequia Research" group).

Supported activities at New Mexico Tech (NMT) include:

- The New Mexico Tech group will take responsibility for the Intense Study Areas (ISA), which examine through observation and modeling how hydrologic processes respond to weather and climate. The larger scale studies examine, on a basin and sub basin scale, what that response is and develop relationships to model that response, but they don't examine which processes determine that response. The small-scale studies in the ISAs examine how and why, as well as what. They will provide process level understanding that is key to predicting how New Mexico's northern mountains will respond to climate change.
- The observations include micrometeorological stations to measure local scale fluxes to and from the atmosphere, runoff plots to examine runoff and deep percolation, and stream gauges to measure streamflow on tributaries and the main stem stream of each of three ISAs in order to link with the water quality and acequia studies. They also include isotopic composition of these fluxes, in order to infer flowpaths and

residence times, and distributed temperature sensing to infer groundwater-surface water interaction and to sense deep percolation.

- Coupled with these and other observations, the modeling will examine how elevation, slope, aspect, sheltering, shadow, vegetation, rock type, soil, and drainage network pattern combine to partition winter snow, spring snowmelt, and summer monsoon into evapotranspiration, runoff, and deep percolation to the mountain bedrock. Coupled with larger scale (and lower dimensional) hydrologic models, they will help explain the observed connection between observed changes in snowpack or other variables and later streamflow. Coupled with climate modeling and scenarios, the small scale models of Intense Study Areas will be used to understand how the hydrologic system responds to changing climate (and changing landcover and landuse).

Participants

Albert Rango at USDA ARS Jornada Experimental Range (Jornada); Todd Ringler at Los Alamos National Labs (LANL); Max Bleiweiss, Leeann Demouche, Caiti Steele, Sam Fernald, and State Climatologist at NMSU; Joe Galewsky at UNM; John Wilson, Fred Phillips, Jan Hendrickx, and new faculty Hydrologist hire at NMT; Bob Parmenter at Valles Caldera National Park (VCNP); Richard Armijo at Natural Resources Conservation Service (NRCS).

Planned Actions and Deliverables by Year

Timeline of Planned Activities and Deliverables/Milestones by Year		
Year 1	Activities	Deliverables/Milestones
NMSU will order and install:	- 3 new and 6 upgraded SNOTEL stations - 4 SCAN stations - 3 new MRGCD climate stations - 2 laptops for field use - All Acequia materials - All Navajo, NMCC, and EBID supplies - All Quikbird data for Acequia systems - Training required - Shipping costs	- Install 9 SNOTEL sites (NRCS) - Install 4 SCAN sites (NRCS) - Install 3 MRGCD sites - Install half of the Acequia sites
NMSU will also:	- Evaluate remote sensing techniques for snow mapping - Develop snow mapping techniques utilizing historic and current satellite data - Develop satellite-based NDVI maps for input to SLURP - Deliver updated SRM model and user manual to EPSCoR NM office and to project personnel working with SRM - Begin installation of SRM on each Rio Grande sub-basin - Begin installation of SLURP on the Rio Grande basin	- Publish 1 journal paper
UNM will:	- Admit 1 graduate (M.S.) student - Develop software interoperability and related procedures	- Professional meeting presentation of initial results
NMT will:	- Confirm Rio Hondo (RH) as the first (ISA) or select an alternative - Delineate the ISA within the Valles Caldera (VC) part of Jemez basin - Using GIS, remote sensing, and other data	- Obtain written permissions to use instrument sites in the VC and RH ISAs obtained - Select the third ISA

	analysis, plan the instrument (channel streamflow stations –CSS, runoff plot discharge stations –RPDS, and the integrated micrometeorological stations –IMS) deployment in both the VC and RH ISAs - Obtain permissions for instrument sites in the VC and RH ISAs - Order first set of CSS, RPDS and IMS instruments - Order Meteor-Burst radios for ISA instrument sites - Begin installation and testing of CSS, CPDS, and IMS instruments in the VC ISA - Order 2 student computers - Begin development of a refined strategy for modeling within the VC and RH ISAs - Select modeling software and obtain license(s) if needed	
	Activities Year 2	Deliverables/Milestones
NMSU will order and install:	- 2 new and 6 upgraded SNOTEL sites - 12 NMCC sites - 5 Navajo sites - 10 RAWS upgrades - 65 Meteor-Burst radios - All replacements parts - Training required - Acequia supplies	- Install 8 more SNOTEL sites (NRCS) - Install 12 NMCC sites - Install 5 Navajo network sites - Install 10 RAWS upgraded sites (USFS) - Install half of the Acequia sites - Install half of the Meteor-Burst radios
NMSU will also:	- Begin development of data management protocols - Construct sub basin snow maps for prior years and current years - Produce simulations with SRM and SLURP for selected sub basins and evaluate performance	- Publish 1 journal paper
UNM will:	- Admit 1 graduate (PhD) student - Develop proof-of-concept interoperable atmospheric/surface processes modeling software framework	- Publish 1 journal paper - Submit 1proposal to NSF GLD - Graduate student presentation at professional meeting
NMT will:	- Select the third ISA (presumably the Rio Brazos) tributary of the Rio Chama - Using GIS, remote sensing, and other data analysis, plan the instrument (CSS, RPDS and IMS) deployment (locations/timing) in the third ISA - Obtain permissions for instrument sites in the third ISA - Order second set of CSS, RPDS and IMS instruments - Order the DTS instrument - Develop ISA data management protocols - Complete installation and testing of CSS, CPDS, and IMS instruments in the VC ISA - Install and test first set of CSS, RPDS and IMS	- Permissions to use instrument sites in third ISA obtained - ISA climate and hydrologic instrumentation installation essentially complete in the Valles Caldera and Rio Hondo ISA

	instruments in the RH ISA - Install Meteor-Burst radios on current ISA instrument sites - Design and test isotope collectors for precipitation; develop protocol for isotope sample collection in streams, runoff plots, and precipitation; begin isotope sampling - Order laser mass spectrometer for isotope analysis - Order and being installation of Field Data Acquisition and Storage System - Order and begin installation of Climate Data Acquisition and Storage System - Complete modeling strategy; begin modeling of the VC and RH ISAs - Test and evaluate modeling software; design needed improvements/additions - Begin collaboration of modeling efforts with the climate, basin scale hydrology, and water quality and acequia groups.	
	Activities Year 3	Deliverables/Milestones
NMSU will order and install:	- Replacement parts - Training required - Acequia supplies - Half of the Meteor-Burst radios	- Complete installation of Acequia instrumentation
NMSU will also:	- NMSU will develop data management protocols - Produce real time snow cover and NDVI maps for all sub basins - Produce simulations for all sub basins and evaluate performance of SRM and SLURP - Produce normalized hydrographs for each sub basin	- Data management protocols - Publish 2 journal papers - Publish 1 graduate thesis
UNM will:	- Apply coupled modeling framework to simple climate scenarios	- Publish 1 journal paper - 1 graduate student thesis completed - Graduate student presentation at professional meeting
NMT will:	- Review the instrument deployment in the ISAs and move instruments as needed - Maintain instruments as needed - Install and test second set of CSS, RPDS and IMS instruments in the third ISA - Install Meteor-Burst radios on remaining ISA instrument sites - Test the DTS unit; develop a protocol and plan for its deployment in this study, and the water quality and acequia studies - Complete installation and testing of Field Data Acquisition and Storage System - Complete installation and testing of Climate Data Acquisition and Storage System - Deploy precipitation collectors at all ISA and acequia sites	- ISA climate and hydrologic instrumentation installation essentially complete in the third ISA - ISA precipitation isotope collectors installed in all ISAs - Quality assured ISA climate, hydrologic, and isotope data being collected - 1 or more presentations at national meeting - Publish 1 journal paper - Submit 1 proposal to NSF GEO

	- Begin modeling of the third ISAs - Identify and design additional improvements or additions needed in the modeling software	
	Activities Year 4	Deliverables/Milestones
NMSU will order and install:	- Replacement parts - Training required - Acequia supplies - Connectivity items	- Complete installation of meteor-burst data relay system - Complete maintenance on all installed instrumentation
NMSU will also:	- NMSU will connect the Meteor-Burst data relay system - Test climate change affected hydrographs using SRM on selected basins in CO and NM - Test SRM forecast procedures on selected basins - Evaluate different climate scenarios and their hydrologic consequences using SLURP	- Conduct workshops on hydrologic modeling for water resources agencies - Publish 2 graduate theses - Publish 2 journal papers
UNM will:	- Admit 1 graduate (M.S.) student - Develop real and/or idealized climate change scenarios for selected basins	- Publish 1 journal papers - 1 proposal submitted to NSF ATM - Graduate student presentation at professional meeting
NMT will:	- Review the instrument deployment in the ISAs and move instruments as needed - Maintain instruments as needed - Deploy precipitation isotope collectors at all ISA and acequia sites; begin deployment at SNOTEL, SCAN and MRGCD sites - Order 2 student computers - Complete additional improvements/additions needed in the modeling software - Using models and observation data test important hydrologic processes in both the snow and monsoon seasons in the three ISAs, accounting for elevation, slope, aspect, soils, vegetation, and other attributes - Intercomparison of SRM and SLURP simulations of the ISAs with detailed models	- Telecommunications with instrumentation and data acquisition system essentially complete in all ISAs - Publish 1 journal paper on hydrologic science, and 1 or more joint papers with climate, basin scale hydrology, water quality and/or acequia groups - 1 or more presentations at national meeting - Submit 1 or more proposals to NSF GEO and other agencies - 1 thesis completed
	Activities Year 5	Deliverables/Milestones
NMSU will order and install:	- Replacement parts - Training required - Acequia supplies - Connectivity items - Maintain Meteor-Burst data relay system	
NMSU will:	- Transfer instruments to state water resources agencies as needed - Produce climate change affected hydrographs using SRM and SLURP on all sub basins - Produce SRM forecast procedures for use on each sub basin - NMSU will conduct workshops to transfer SRM and SLURP techniques to water resource agencies	- Transfer instruments to appropriate agencies - Conduct workshops on climate and hydrologic modeling for water resources agencies - Publish 3 journal papers - Publish 4 graduate theses
UNM will:	- Hand off model coupling infrastructure to	- Publish 1 journal paper

	CSDMS repository	- 1 graduate student thesis completed - Graduate student presentation at professional meeting
NMT will:	- Review the instrument deployment in the ISAs and move instruments as needed - Maintain instruments as needed - Complete deployment of precipitation isotope collectors at SNOTEL, SCAN and MRGCD sites - Using models and observation data test important hydrologic processes in both the snow and monsoon seasons in the three ISAs, and their response to climate change, accounting for elevation, slope, aspect, soils, vegetation, and other attributes - Complete modeling of ISAs - Transfer of ISA instruments, as appropriate, to water resources agencies - Remaining ISA instrument sites continued by NM EPSCoR institutions or removed from the field and made available for other NM projects	- Complete maintenance on all ISA instruments - Transfer appropriate instruments to agencies or institutions - Conduct workshops on climate and hydrologic modeling for water resources agencies - Publish 1 journal paper on hydrologic science, and 1 or more joint papers with climate, basin scale hydrology, water quality and/or acequia groups. - 1 or more presentations at national meeting - Submit 1or more proposals to NSF GEO and other agencies - 2 theses or dissertations completed

Resources Provided

- Salary support to include: State Climatologist, water resources specialist, range hydrologist, agricultural economics modeler, post-doctoral associate and field technical at NMSU; climate modeler at UNM; environmental chemist and 2 hydrologists at NMT. NMT also has IT system support services. In addition, support for undergraduate students at all three institutions, and graduate students as specified per below.
- NMSU Grad Students (A-G):
  - Year 1 A (Bleiweiss)
  - Year 2 A, B (Rango), C (Fernald)
  - Year 3 B, C, D (Bleiweiss)
  - Year 4 D, E (Demouche), F (Hurd), G (State Climatologist)
  - Year 5 D, E, F, G
- UNM graduate and undergraduate students will be advised by Galewsky.
- NMT graduate and undergraduate students will be advised by NMT senior faculty.
- Equipment support to include: streamflow and runoff discharge systems, hydrometeorological stations, a Meteor-Burst Data Relay Network, laboratory water quality instrumentation at NMT; 4 new SCAN sites, 5 new SNOTEL sites and 12 SNOTEL site upgrades, 3 new Middle Rio Grande observation sites, 12 new NM Climate Center sites, 5 Navajo Nation Data Stations, 10 RAWS upgrades, and necessary field laptops/computers at NMSU.
- Travel funds for fieldwork, annual EPSCoR meetings, and for research collaboration meetings.
- Materials and supplies are in support of the field research activities described and the equipment purchases listed above.

Efforts to Promote Sustainability

NMSU Efforts

- Management and ongoing financial support of installed instrumentation and equipment will be assumed by state and federal water management agencies as per the following: 9 SNOTEL sites assumed by NRCS in Year 1; 8 SNOTEL sites and 4 SCAN stations assumed by NRCS in Year 2; MRGCD climate stations assumed by MRGCD in Year 1; 12 new NMCC stations assumed by NMCC in Year 2; Navajo climate stations assumed by Navajo Nation in Year 3; Acequia sites assumed by local acequia associations in Years 3 and 4; RAWS sites assumed by USFS in Year 3; Meteor-Burst data relay assumed by NMCC in Year 4.

- Workshops on SRM and SLURP models will be held for local, state, and federal agencies in Years 4 and 5 to enhance utilization of the models.
- Operational modeling on sub basins will be transferred to water management agencies in Year 5.

UNM Efforts

- The graduate program will be sustained by the submission of proposals in years 2 and 4.
- New software developed for model interoperability will be handed off to CSDMS program in years 3 and 5.

NMT Efforts

- Management of some ISA instruments assumed by appropriate agencies.
- Remaining ISA instruments maintained by the NM EPSCoR institutions. (Either in place, or removed to other sites for related NM-based research).
- The DTS and laser mass spectrometer will be transferred to host institutions for use in other research and applied projects.

Summary and Changes in Planned Activities Since Proposal

There are no changes in the overall scope of work. Changes are related to delays due to the actual availability of funds.

Changes in major equipment and instrumentation: The basic thrust and purpose of the intensive study area (ISA) remains as outlined in the proposal. The main change is due to delay in the funding. The ISA instrumentation will be installed somewhat later than originally proposed, but essentially all of it will be operational by the end of Year 3. Modeling efforts are similarly delayed. This should not diminish the overall contribution of the ISA effort over the duration of the project.

There has been a change in equipment, reducing the number of channel streamflow stations (CSS), runoff plot discharge stations (RPDS), and integrated micrometeorological stations (IMS), by 25% on average. This reduces the number of installations needed and makes it possible to install the entire reduced system almost on the original schedule. However, this is not the main reason for the proposed shift. The freed funds will be used to purchase two other important pieces of equipment to support the fieldwork for the ISAs, the acequia study, and the related water quality study. These two purchases will bring substantial improvements to the research infrastructure of New Mexico, with reach well beyond the focus of the current project. The first is a laser mass spectrometer and associated collection systems for isotope samples. Isotopic composition in precipitation, runoff, groundwater, and streamflow is a function of season, slope, aspect, elevation, rock, soil, vegetation, and land use. It is one of the best measures of the flow path and residence time of water in mountain systems. Coupled with the physical measurements of water and energy fluxes in the other instrumentation, the isotope measurements will provide far more information on processes than would a few more ISA climate/hydrologic instruments. The second is a Distributed Temperature Sensing (DTS) unit. It is a field portable instrument that measures temperature in a fiber optic cable, which looks something like a fishing line, and can be as long as 15km. When the DTS is connected to a cable (or multiplexed to several cables) it provides high quality temperature data on a 1meter, 5minute space and time scale. Cables will be installed in reaches of the main channel and tributaries of the ISA drainages and in the downstream acequias. Temperature variation in space/time will be used to diagnose the groundwater-surface water connections, and will supplement the other physical, isotopic, and water quality data in inferring flow paths, residence times, and processes. Cable can also be buried in the soil at the RPDSs to infer deep percolation and recharge. The instrument will be deployed in campaign style. Both instruments have many other applications and will have long-term impact beyond this project.

Changes in personnel. Deborah Bathke, New Mexico State Climatologist, has left NMSU. The Department of Plant and Environmental Sciences is in the process of hiring a new Climatologist to be selected by February 2009 and to be on board by June 2009. They will not need one-month summer salary in first year, but will need it after the first year. For the first year only, we propose giving it to Dr. Sam Fernald to assist in his acequia startup efforts. NSF approval will be requested. At UNM, there will be delays in hiring and start dates of graduate students and there will be impact on budget carryover. The original NMT PI, Enrique Vivoni, has accepted a faculty position at a university in Arizona and will be leaving the project. John L. Wilson will replace him as NMT PI, pending NSF

approval. Wilson is a Professor of Hydrology and former director of the Hydrology Program at NMT. A senior researcher, he is also former Chairman of CUAHSI and current President of the 7,000 member of the Hydrology Section of the American Geophysical Union. Listed as a senior investigator in the original proposal, one of his major research areas is mountain hydrology. His work spans mathematical modeling, laboratory studies, and field observation. Vivoni is one of the major developers of tRIBS, the proposed code for the ISA modeling. Wilson is familiar with the code, but is not a developer. During the first year of the project, the choice of code will be reconsidered. However, the default decision will be to stay with tRIBS. A new junior faculty member will be hired by NMT in the same general field as Dr. Vivoni. It is appropriate that this new faculty member will be added to the project when s/he arrives, which appears likely to be in Year 3.

Activity 2: Water Quality

Strategic Objectives

Design and deploy real-time, continuous in-stream sensors of chemical constituents important for ecosystem and human health in snowmelt-dominated watersheds, including synoptic sampling for sensor validation and longitudinal studies.

Activities Supported

- Develop new and apply existing water quality sensors for the autonomous monitoring of stream waters in high altitude environments.
- Deploy a set of state-of-the-art, near-real-time, autonomous water quality sensors for monitoring the quality of surface water in at least two watersheds in New Mexico that are fed by snowmelt.
- Establish a water analysis laboratory at New Mexico Highlands University that will be utilized for water quality testing during this project and for the education of undergraduate and graduate students. This objective is further developed under the planning category "Critical Gap Infrastructure for New Mexico Highlands University". Researchers at NMHU form part of the water quality group.
- In collaboration with the hydrology group, use data from co-located hydrology sensors and the water quality monitors to understand the controls on water quality in each watershed.
- Develop a diverse group of interdisciplinary and multi-institution collaborators, facilities, and educational efforts within New Mexico concerned with understanding stream water chemistry dynamics.

Participants

Cliff Dahm, Laura Crossey at UNM; Mike Pullin, Robert Bowman at NMT; Edward Martinez at NMHU; Marnie Caroll at Dine College

Planned Actions and Deliverables by Year

Timeline of Planned Activities and Deliverables/Milestones by Year	
Activities Year 1	Deliverables/Milestones
- Evaluate possible watersheds and possible sensor locations within the watersheds - Choose locations for the first set of sensors, including water sampling and analysis - Locate and evaluate commercially available sensors - Purchase one set of sensors - Develop a deployment strategy for the first sensor package, including site selection and permissions and a communications strategy (in collaboration with other EPSCoR research groups) - Deploy the first sensor package - Begin development of the iron sensor - Monitor stream water quality using the first sensor package - Evaluate the quality of the data obtained by the sensors through the use of sample collection and analysis campaigns - Conduct reconnaissance synoptic sampling campaigns for additional water quality parameters - Evaluate the success of the deployment strategy and the sensor package capabilities - If requested, begin to develop data delivery strategy	- First watershed for sensor deployment chosen - Commercially available sensors chosen and purchased - Deployment strategy for the first sensor package developed and implemented - Data delivery strategy and format developed - Water analysis lab at NMHU established - Water quality group members participated in NM EPSCoR outreach events as requested - At least 2 UROP participants supervised - At least 3 water quality group members attend the spring multi-state EPSCoR meeting - Conference presentations

and format for the webpage, in collaboration with the communications coordinator - Purchase and install chemical analysis instrumentation at NMHU - Supervise at least two UROP participants during Summer 2009 - Participate as requested in NM EPSCoR outreach activities, such as the science cafes and teacher workshops - Attend the spring multi-state EPSCoR meeting	
Activities Year 2	Deliverables/Milestones
- If needed, modify the deployment strategy as determined by the year 1 results - Continue to monitor stream water quality using the first sensor package - Continue to evaluate the quality of the data obtained by the sensors through the use of sample collection and analysis campaigns - Continue to conduct synoptic sampling campaigns for additional water quality parameters, including isotopic analyses - Conduct a second evaluation of the success of the deployment strategy and the sensor package capabilities - Continue the development of iron sensor, including field testing and initial deployments - Interpret the data collected with regard to understanding the controls on stream water quality - Survey available water quality models and identify appropriate models if available - Deliver water quality data to the NM EPSCoR website, in collaboration with the communications coordinator - Supervise at least two UROP participants during Summer 2010 - Participate as requested in NM EPSCoR outreach activities, such as the science cafes and teacher workshops - Attend any statewide or multi-state EPSCoR meetings	- Based on year 1 data, sensor package implementation improved - A prototype iron sensor device developed and field tested - Year 1 and 2 water quality data delivered to NM EPSCoR webpage - Available water quality models surveyed and appropriate models identified - Water quality group members participated in at least 2 NM EPSCoR outreach events - At least 2 UROP participants supervised - At least 1 collaborative research proposal submitted by water quality group members - Peer-reviewed journal articles and conference presentations submitted on design and implementation of the sensor package, and Year 1-2 data interpretation - 5 undergraduate students and 2 graduate students trained in NMHU water analysis lab
Activities Year 3	Deliverables/Milestones
- If needed, modify the deployment strategy as determined by the year 2 results - Continue to monitor stream water quality using the first sensor package - Continue to evaluate the quality of the data obtained by the sensors through the use of sample collection and analysis campaigns - Continue to conduct synoptic sampling campaigns for additional water quality parameters, including isotopic analyses	- Second and possibly third sensor package purchased and deployed - Iron sensor device deployed at two or three sites - Year 3 water quality data delivered to NM EPSCoR webpage - Water quality group members participated in at least 2 NM EPSCoR outreach events - Water quality models parameterize and tested - 5 undergraduate students and 2 graduate students trained in NMHU water analysis lab

- Deploy the iron sensor at the site of the first sensor package - Reevaluate commercially-available sensor technology - Purchase and deploy the second and possibly third sensor package(s) - Purchase and deploy water quality sondes in selected locations at the sites - Interpret the data collected with regard to understanding the controls on stream and acequia water quality - Parameterize and test available water quality models - Collaborate with non Ph.D. institutions to assist in submissions of appropriate seed grants to enhance research infrastructure - Deliver water quality data to the NM EPSCoR website, in collaboration with the communications coordinator - Supervise at least two UROP participants during Summer 2011 - Participate as requested in NM EPSCoR outreach activities, such as the science cafes and teacher workshops - Attend any statewide or multi-state EPSCoR meetings	- At least 2 UROP participants supervised - 0-2 collaborative research proposals submitted by water quality group members, depending on the success of the year 2 proposals - Peer-reviewed journal articles and conference presentations submitted on sensor package, and Year 1-3 data interpretation - 1 Ph.D. or M.S. degree granted to a graduate student for water quality project-related research
Activities Year 4	Deliverables/Milestones
- Continue to monitor stream water quality using the deployed sensor packages - Continue to evaluate the quality of the data obtained by the sensors through the use of sample collection and analysis campaigns - Continue to conduct synoptic sampling campaigns for additional water quality parameters, including isotopic analyses - Deploy water quality sondes in selected locations at the sites - Interpret the data collected with regard to understanding the controls on stream and acequia water quality - Develop or adapt reactive transport models to simulate observed water quality data - Collaborate with non Ph.D. institutions in seed grant funded research - Supervise at least two UROP participants during Summer 2012 - Participate as requested in NM EPSCoR outreach activities, such as the science cafes and teacher workshops - Attend any statewide or multi-state EPSCoR meetings	- Year 4 water quality data delivered to NM EPSCoR webpage - Reactive transport models developed or adapted to simulate observed water quality data - 5 undergraduate students and 2 graduate students trained in NMHU water analysis lab - Water quality group members participated in at least 2 NM EPSCoR outreach events - At least 2 UROP participants supervised - 0-2 collaborative research proposals submitted by water quality group members, depending on the success of the year 3 proposals - Peer-reviewed journal articles and conference presentations submitted on Year 1-3 data interpretation - 2 Ph.D. or M.S. degrees granted to graduate students for water quality project-related research
Activities Year 5	Deliverables/Milestones

- Continue to monitor stream water quality using the deployed sensor packages - Continue to evaluate the quality of the data obtained by the sensors through the use of sample collection and analysis campaigns - Continue to conduct synoptic sampling campaigns for additional water quality parameters, including isotopic analyses - Deploy water quality sondes in selected locations at the sites - Interpret the data collected with regard to understanding the controls on stream and acequia water quality - Refine reactive transport models to reflect the observed data - Collaborate with non Ph.D. institutions in seed grant funded research - Supervise at least two UROP participants during Summer 2013 - Participate as requested in NM EPSCoR outreach activities, such as the science cafes and teacher workshops - Attend any statewide or multi-state EPSCoR meetings	- Year 5 water quality data delivered to NM EPSCoR webpage - Reactive transport models refined to reflect the observed data - 5 undergraduate students and 2 graduate students trained in NMHU water analysis lab - Water quality group members participated in at least 2 NM EPSCoR outreach events - At least 2 UROP participants supervised - 0-2 collaborative research proposals submitted by water quality group members, depending on the success of the year 4 proposals - Peer-reviewed journal articles and conference presentations submitted on Year 1-4 data interpretation - 2 Ph.D. or M.S. degrees granted to graduate students for water quality project-related research

Resources Provided

Some resources listed under the Water Quality plan are also utilized by the "Acequia and Socioeconomics" group. The "Critical Gap Infrastructure for New Mexico Highlands University" section specifically discusses resources for the NMHU water quality lab. In addition, resources described above for "Climatology and Hydrology Research" are also applied to the water quality research. Resources provided include personnel, travel and materials and supplies:

- Salary support for Pullin at NMT. Funding for graduate student advised by Crossey at UNM for deployment and monitoring of the sensors. Graduate student advised by Pullin at NMT.
- Funding for the purchase of water quality sensor systems for 3 watersheds, to include all instrumentation, electronics and computers related to the system installation; funds to UNM and NMT.
- Laboratory and field supplies for the support and maintenance water quality sensors; funds to UNM an NMT.
- Funding for graduate student/s advised by Crossey at UNM.
- Travel related to the deployment and monitoring of the sensors in the field.

Efforts to Promote Sustainability

Water quality research will be sustained through the investment in the sensor network, the investment in the NMHU water analysis laboratory, and the formation of ongoing collaborations. The development and installation of the in-stream water chemistry sensors forms a foundation upon which future proposals can build. Submitted proposals will fund the continued use and expansion of the water quality sensing network. Likely NSF programs include Low Temperature Geochemistry and Biogeochemistry, Hydrology, Ecosystems, and any crosscutting programs that occur during the grant period. The water analysis laboratory at NMHU (discussed under "Critical Gap Infrastructure for New Mexico Highlands University") will be sustained by NMHU after year 5 of this proposal. Collaborations developed during the project will promote continued research on water quality in New Mexico.

Summary and Changes in Planned Activities Since Proposal

The research group in water quality is well established with a cohesive working relationship and a shared vision of well-defined strategic objectives. There are no significant personnel changes since the original proposal. There are no changes in the overall scope of work, or in the resources available for the research.

The delay in start date effects the advertising and hiring of graduate students. The 12-month graduate student funding in Year 1 will be used to fund several graduate students during Summer 2009 for fieldwork.

Activity 3: Socioeconomics and Acequia Research

Strategic Objective

The strategic objective is to develop interdisciplinary socioeconomic and acequia research capacity in three areas: 1) traditional acequia hydrology and socio-cultural institutions; 2) agro-ecosystems; and 3) urban demand. The research promotes interdisciplinary collaboration among social, economic, and hydrologic science researchers on topics of concern for water resource managers in New Mexico.

Acequia hydrology and socio-cultural institutions strategic objectives: 1) characterize acequia system flow distribution and hydrological interactions between surface water and ground water flow in two different acequia systems that serve as tributaries to the Rio Grande; 2) document the ancient customs and traditions of acequia systems in two tributaries of the Rio Grande during times of climate variability and effects on human adaptation.

Agro-ecosystem economics strategic objective: Improve the understanding and management of water in New Mexico's agro-environmental systems, and increase the ability to assess both short- and long-run consequences of management and technological improvements in agricultural production, including agricultural and environmental productivity, water quality, economic performance, and effects on surface and sub-surface hydrology. A more specific objective is to assess the feasibility and strategic application of the existing small watershed scale decision support tool known as CROPMAN© and APEX© for use in the study area. These models are currently developed for agricultural systems in Texas, and require re-parameterization and additional datasets in order to be applied to the study area.

*Economic-behavioral-physical strategic objective*s: Improve the understanding of inter-related human and physical systems to assist in future decisions on adaption to climate change. Specific objectives are: 1) extend the systems dynamics Toolbox simulation model (developed by Sandia National Laboratories) to include improved Middle Rio Grande residential water demand models and a population growth model driven by natural and economic growth; 2) explore the potential for developing acequia and agro-ecosystem dynamic systems model components, and if feasible, build and incorporate the components into the Toolbox model developed by Sandia National Labs. This would allow a comparison across different coping methodologies within an interactive framework.

Activities Supported

- *Acequia hydrology.* Install critical and innovative infrastructure in two important and understudied watersheds with acequia systems that serve as tributaries to the Rio Grande. Identify components and linkages between components of acequia systems in terms of physical hydrology including valley water balance and acequia system retransmission of flow from early spring to late summer runoff. Use remote sensing analysis of high-resolution satellite data (QuickBird) to map acequia channels, irrigated land areas, and riparian vegetation in the Río Hondo and Río Chama intensive study basins. Instrumentation to measure the effects of acequias on downstream flow will be installed in these basins. Coordination with NMT hydrology and water quality components will add multiple capabilities such as flow path characterization with water sample isotopic concentrations, automated in-situ ion concentrations, and distributed surface water and ground water temperatures. Simulation models, likely Hydrus-2D or MODFLOW, will be used to synthesize field measurements to characterize acequia effects on water budgets.
- *Acequia socio-cultural institutions*. Characterize acequia socio-cultural institutions and robustness of acequia systems in the face of climatic variation, because acequias are gravity fed and rely on snowmelt runoff. Organize Acequia Focus Groups in each of the two watersheds to present changing hydrological models and scenarios that reduce flows from mountain snowpack into acequia headgates in the spring and early summer. Facilitate discussion of socio-economic impacts of changing hydrological conditions on traditional irrigation practices, cropping patterns and land use, water sharing agreements, storage facilities, and administration of priority dates. Evaluate cultural responses and resilience of New Mexico's acequias under conditions of reduced water supply as presented to the Acequia Focus Groups in the data and simulation models. Monitor riparian health based on impacts of changing hydrology. Develop EPSCoR graduate student and stakeholder driven partnership in ongoing riparian monitoring effort.

- *Agro-ecosystem economics.* Support the assessment and pilot application of either the CROPMAN or APEX agricultural modeling system at a farm- or small watershed-level. These models were designed to simulate farm-level agricultural systems across a variety of cropping systems, management and technologies, soil types, and climatic conditions. The models simulate, for example, the cycling and carryover of nutrients, soil moisture, and salinity across seasons making them well suited to long-run assessments regarding irrigation and water quality management under various cropping systems and management strategies. A key aspect of this effort will be to assess the necessary model changes for application to the study areas to make appropriate modification of agronomic, cropping, management, soils, climate and economic databases to reflect crops, conditions, management, and technology available to farmers in New Mexico.
- *System dynamics economic-behavioral-physical model.* Explore the potential to support the expansion of the Sandia Toolbox model to include: more robust residential demand models for Albuquerque; a population model tied to both natural growth and economic growth (driven by a macro modeling component based on input-output analysis); an acequia model for the Río Chama; a water irrigation and decision support system for farms in the Middle Rio Grande River and Río Chama acequia system. This expanded dynamic simulation model will provide one of the most extensive interactive models of a watershed system with equal attention to the physical and behavioral worlds. The focus on the two farming technologies will allow in-depth comparison of coping mechanisms. The expanded urban model will provide a platform in which to assess economic, drought, and climate policies.

Participants

Janie Chermak, Bill Fleming, and Jose Rivera at UNM; Sam Fernald, Steve Gulden, Brian Hurd, Caiti Steele, Carlos Ochoa, Julie Maitland at NMSU; Al Rango at USDA ARS Jornada Experimental Range; Vince Tidwell at Sandia National Labs (SNL); Palemon Martinez with community acequia management

Planned Actions and Deliverables by Year

Timeline of Planned Activities and of Deliverables and Milestones by Year		
	Activities Year 1	Deliverables and Milestones
	- Coordinate with hydrology group and water quality group	- Explore possibilities for NSF funding of hydrologic economic valuation of multiple acequia functions supported including: water quality protection, wildlife habitat, grazing areas, and aesthetics
Acequia hydrology and socio-cultural institutions	- Purchase acequia materials and supplies - Initiate installation of acequia hydrology measurement equipment at Rio Hondo site - Acquire and process acequia hydrology data - Identify acequia association collaborator in Rio Chama watershed - Organize Focus Group at Rio Hondo site with the collaboration of the Taos Valley Acequia Association - Begin socio-cultural work at Rio Chama site	- Identify acequia materials and supplies to purchase - Acequia materials installation begun at Rio Hondo site
Agro-ecosystems economics	- Characterize regional agricultural and economic conditions, practices, and opportunities at the study site - Review CROPMAN and APEX model parameters and identify necessary New Mexico-specific additions and changes	- Memo on agricultural production in the study area and describe progress and feasibility of CROPMAN and APEX model application to study site

Systems dynamics economics	- Complete econometric modeling of Albuquerque residential demand using data gathered from SAHRA research - Review and modify population modeling component previously developed for the Toolbox - Begin to assess micro-macro interactions within the Toolbox. Develop necessary (if any) modeling interaction changes	- Residential Demand Model Developed - 1 grant proposal submitted (interdisciplinary modeling)
	Activities Year 2	Deliverables and Milestones
	- Coordinate with education and cyberinfrastructure groups	- Submit grant proposal for funding of hydrologic economic valuation of multiple acequia functions supported including: water quality protection, wildlife habitat, grazing areas, and aesthetics
Acequia hydrology and socio-cultural institutions	- Initiate installation of acequia hydrology measurement equipment at Rio Chama site - Acquire and process acequia hydrology data - Organize Focus Group at Rio Chama site - Conduct Exploratory Research Focus Group sessions and interviews at Rio Hondo site	- Acequia materials and equipment installation begun at Rio Chama site - 1 paper submitted
Agro-ecosystems economics	- Acquire support and training models - Initiate dataset and parameter development	- Memo describing progress in training and dataset development
Systems dynamics economics	- Student training on PowerSim system dynamics model and familiarization with existing Sandia toolbox - Program residential water demands and the population models and link to the Toolbox - Assess Toolbox outcomes, plan modifications	- 1 paper submitted (dynamic simulations) - Student research requirement paper submitted
	Activities Year 3	Deliverables and Milestones
Acequia hydrology and socio-cultural institutions	- Begin transfer of acequia hydrology measurement system to Rio Hondo acequia group - Acquire and process acequia hydrology data - Conduct Exploratory Research Focus Group sessions and interviews at Rio Chama site. - Conduct second Rio Hondo focus group including integrated scenarios.	- Maintain acequia hydrology measurement equipment - Graduate student degree completed with thesis or project - 1 joint hydrology sociocultural paper prepared
Agro-ecosystems economics	- Continue dataset and parameter development	- Memo describing progress in training and dataset development.
Systems dynamics economics	- Modify Toolbox as necessary - Develop scenarios - Assess outcomes	- 1 dissertation proposal developed and defended - 1 paper submitted
	Activities Year 4	Deliverables and Milestones

	- Integrate hydrologic, socio-cultural, and economic facets of acequia systems in system dynamics model	- Integrated conceptual model paper
Acequia hydrology and socio-cultural institutions	- Begin transfer of acequia hydrology measurement system to Rio Chama acequia group - Acquire and process acequia hydrology data - Conduct second Rio Chama focus group including integrated simulation	- Maintenance of acequia hydrology measurement equipment - 1 paper submitted - Graduate student degree completed with thesis or project
Agro ecosystems economics	- Calibrate and validate prototype model for use in study area	- Memo describing efforts to validate and calibrate model prototype to the study area
Systems dynamics economics	- Begin Acequia and Agro-ecosystems model within the systems dynamics framework; assess the potential for linkages to the Toolbox - Begin linking acequia and agro-ecosystems model to Toolbox, if feasible	- Grant proposal submitted - 1 paper submitted
	Activities Year 5	Deliverables and Milestones
Acequia hydrology and socio-cultural institutions	- Integrated analysis distribution to acequia communities - Complete transfer of acequia hydrology measurement systems to local acequia groups	- Graduate student degree completed with thesis or project - 1 paper submitted - Simulation model of the surface water-ground water interactions in an acequia system
Agro-ecosystems economics	- Communicate and disseminate model results and capabilities including development of guidance for further efforts, extension and education processes	- Report on model results, capabilities, and guidance for further efforts
Systems dynamics economics	- Complete Toolbox components - Develop scenario driven Toolbox download model for informational, policy, and educational purposes	- Dissertation defended - 3 papers submitted from graduate student work - Toolbox download

Resources Provided

Resources listed under the Climate and Hydrology Research plan are also utilized by the Acequia and Socioeconomics group and are not duplicated here.

- Funding for graduate student/s advised by Fernald (NMSU) in hydrology, graduate student/s advised by Hurd (NMSU) in economics, graduate student/s advised by Rivera and Fleming (UNM) in Regional Planning, and graduate student/s advised by Chermak (UNM) in economics.
- Funding for 5 undergraduate students to work with faculty at NMSU and UNM.
- Materials and supplies.
- Travel expenses to field research sites for investigators and graduate students (NMSU and UNM) and travel to EPSCoR meetings.

Efforts to Promote Sustainability

The acequia water resources research includes a significant investment in technology transfer to local communities and their water management organizations. The acequia hydrology measurement system operation and data processing will be assumed by local acequia groups. Their involvement and training has been included in the activities planning. In addition, riparian monitoring methods that are tied to both the acequia research and the

water quality research, will be transferred to local acequia management communities and establishment of an ongoing riparian monitoring effort.

The systems dynamics Toolbox model will be provided to government water resource managers and can be used for scenario driven policy evaluation.

Summary and Changes in Planned Activities Since Proposal

The research group in Socioeconomics and Acequia is well established with a cohesive working relationship and a shared vision of well-defined strategic objectives. There are no significant personnel changes since the original proposal. There are no changes in the overall scope of work, or in the resources available for the research.

The delay in start date effects the advertising and hiring of graduate students. It also affects the purchase and installation of the stream monitoring instrumentation.

Activity 4: Critical Gap Infrastructure for New Mexico Highlands University

Strategic Objective

Complete a major upgrade to the aquatic chemistry laboratory at New Mexico Highlands University (NMHU) for state-of-the-art water quality analysis that enhances NMHU's ability to perform research on climate change and water resources.

Activities Supported

Equipment and instrumentation will be purchased that will enable the aquatic chemistry lab at New Mexico Highlands University to perform chemical analyses on water samples. Graduate and undergraduate students will receive training on the instrumentation that is acquired. New Mexico Highlands University is a regional HSI with a student population predominantly from communities in northern and northeastern New Mexico. NMHU offers undergraduate and graduate degree programs in Natural Resource Management and Environmental and Earth Sciences, including advanced coursework in geology and water resources. The proposed new equipment and major research instrumentation upgrades to NMHU's water chemistry lab will support up to 16 faculty and graduate students that currently send water samples to other labs for processing.

Participants

Edward Martinez and Science Faculty at NMHU; Cliff Dahm, Laura Crossey at UNM; Mike Pullin, Robert Bowman at NMT; Marnie Carroll at Dine College.

Planned Actions and Deliverables by Year

Timeline of Planned Activities and of Deliverables and Milestones by Year	
Activities Year 1	Deliverables/Milestones
- Purchase and installation of the FS3100 Automated Chemistry analyzer and Programmable Digestion System (already purchased with funding from NSF-MRI) and participate in user training - Purchase and set up Hydrolab Water Quality Sonde (already purchased with funding from NSF-MRI) - Order and install the Zeeman GFAA Spectrometer and participate in user training - Order and install Ion Chromatograph and participate in user training - Order and install Total Organic Carbon Analyzer 1030W and participate in user training - Identify Lab Tech for maintenance and up keep of instrumentation - Collaborate on potential research projects with other EPSCoR Researchers - Start 1 graduate student on Research project - Train graduate student to use instrumentation	- All instrumentation purchased and installed - Instrumentation training for PI and one grad student - Lab technician hired
Activities Year 2	Deliverables/Milestones
- Train graduate and undergraduate students to use instrumentation - Provide faculty training workshop for each instrument - Continue collaboration with other faculty - Identify 2nd and 3rd gradate student - Incorporate use of instruments in course curricula	- 1 training workshop for interested faculty and students - Incorporated use of instrumentation into courses

Activities Year 3	Deliverables/Milestones
- Start graduate students on Research projects - Train students to use instrumentation - Provide faculty training workshop for each instrument - Incorporate use of instruments in course curricula - Continue collaboration with other research faculty	- Completion of 1 thesis by graduate student - 5-10 undergrads received training in using instruments - 4-6 graduate students received training using instruments - 1 training workshop for interested faculty and students - Submission of article on the establishment of the aquatic chemistry laboratory to university web site and local newspaper - Presentation of research projects at a scientific conference - Submission of research proposal with colleagues
Activities Year 4	**Deliverables/Milestones**
- Identify 4th, 5th, and 6th grad student - Identify Research Projects for grad students - Train students to use instrumentation - Provide faculty training workshop for each instrument - Incorporate use of instruments in course curricula - Continue collaboration with other research faculty	- 5-10 undergrads have received training using instruments - 4-6 graduate students received training using instruments - Provided 1 training workshop for interested faculty and students - Incorporated instruments into course curricula - Presentation of research projects at a scientific conference - Submission of research proposal with colleagues
Activities Year 5	**Deliverables/Milestones**
- Continue to work on research projects with students - Continue to incorporate use of instruments in course curricula - Provide faculty training workshop for each instrument - Incorporate use of instruments in course curricula - Continue collaboration with other research faculty	- 5-10 undergrads have received training using instruments - 4-6 graduate students received training using instruments - Provided 1 training workshop for interested faculty and students - Incorporated instruments into course curricula - Presentation of research projects at a scientific conference - Submission of research proposal with colleagues - Submission of manuscript to journal

Resources Provided

- Salary support for Martinez at NMHU. Funding for one graduate student in Year 1-2, two graduate students in Year 3 and three graduate students in Years 4-5, to include tuition. Two undergraduate students per year for Years 1-5.
- Major instrumentation and equipment purchases for water chemistry analyses:
  - Zeeman GFAA Spectrometer
  - Ion Cromatograph
  - Hydrolab Sonde Water Quality Monitoring System
  - FS3100 Automated Chemistry Analyzer
  - Programmable digestion system
- Travel mileage and per diem for 15 trips per year to field sites for data collection and to project meetings and collaborative research, for Years 1-5.

Efforts to Promote Sustainability

The aquatic chemistry lab will be supported by funding commitments from NMHU and, to a lesser extent, by revenues generated by fees for sample analyses. NMHU has committed to funding one full time laboratory technician position, and providing all funds for the operation and maintenance of the instruments. None of the instruments require special ventilation or power, therefore are relatively easy to install and no renovations will need to be made to the laboratory. The PI and lab technician will receive training in any aspects of the instrumentation that they are not familiar with, and will then oversee operation of the instruments and training, advice and supervision to interested faculty and students. Instrument maintenance and repair will be supported by both the University and through the full time lab technician position. To further assure sustainability, the instrument will be available for water sample analyses by researchers outside the University. The Administrative Accounting unit at NMHU and the PI will set up a billing account for such users. Scheduling will be on a first-come, first-serve basis. Actual per hour operating costs will be tallied by the PI and the lab technician. Based on previous research by the PI at Washington State University, and costs from professional laboratories, the initial per sample cost estimate is $34-$55 depending on the chemistry needed.

Summary and Changes in Planned Activities Since Proposal

The critical infrastructure upgrades to the aquatic chemistry lab at NMHU are closely aligned with and integrated into the research of the water quality group. The integrated research group is well established with a cohesive working relationship and a shared vision of well-defined strategic objectives. There are no significant personnel changes since the original proposal. There are no changes in the overall scope of work, or in the resources available from EPSCoR for the research.

Funding was acquired by Edward Martinez to purchase an FS3100 auto chemistry analyzer and digital block digester through the NSF-MRI Program. Therefore, the funding that was going to be spent on purchasing those instruments from the EPSCoR budget will be used to purchase an Ion Chromatograph and a Total Organic Carbon Analyzer. The Chromatograph and TOC Analyzer will further enhance the aquatic chemistry laboratory. Researchers will have the opportunity to expand their focus on water quality issues due to the enhanced analytical capabilities.

The delayed award date of the grant may shift the first year grad student placement to the second year.

Activity 5: Innovation Working Groups

Strategic Objective

Innovation Working Groups (Wigs) will provide an optimal venue for engaging a critical mass of NM scientists and educators along with key nationally and internationally recognized experts to address the grand challenges that can transform science and education. This program supports week-long working group activities that are modeled after those hosted by the highly successful NSF-supported National Center for Ecological Analysis and Synthesis (NCEAS). Scientists from around NM as well as national and international experts will be invited. A strategic objective of the IWGs is the submission of proposals that target NSF cross-cutting programs and the publication of synthesis papers.

Activities Supported

- Five IWGs will be supported annually by EPSCoR funds. An IWG supports 8-12 scientists or educators who will work collaboratively to integrate and synthesize data, information, and knowledge on challenging issues. IWG topics will be distributed among the climatological, hydrological, and socioeconomic sciences, as well as research topics related to education, communication and outreach, and diversity. At least one IWG each year will focus on education, communication and outreach, or diversity.
- *Bridging Disciplines and Bridging Scales*. A capstone of the program is an IWG that will be partially supported by and held each year at LANL— entitled: "Bridging Disciplines and Bridging Scales." The focus will be on how we relate changes in the physical climate to the socioeconomic impacts. Major themes will be how to institute connections across disciplines (e.g. climate change, surface hydrology, economic modeling) and how to bridge the tremendous gaps in spatial and temporal scales (e.g. from global climate to economic impacts in NM).
- *Tri-State NSF EPSCoR IWGs*. Three western NSF EPSCoR states, Nevada, NM and Idaho have chosen climate change as an overall theme in the present RII competition. NM EPSCoR will host two tri-state NSF EPSCoR IWGs on climate change, "Regional EPSCoR Workshop: Addressing Climate Change Research and Education Challenges in the Western United States", thereby promoting regional and inter-jurisdictional collaborations.

Participants

Scientists and educators throughout New Mexico, including LANL, SNL, NV EPSCoR, ID EPSCoR, and others, selected through the proposal process, which will be coordinated by the NM EPSCoR State Office.

Planned Actions and Deliverables by Year

Timeline of Planned Activities and Deliverables/Milestones by Year	
Activities Year 1	Deliverables/Milestones
- Develop proposal template - Solicit proposals for IWG Workshops - Select proposals through peer-review process, coordinate with LANL for Workshop, "Bridging Disciplines and Bridging Scales" - Hold Workshops, develop plans to write synthesis papers - Develop plans to submit NSF cross-cutting program proposals - Perform evaluation and assessment of Workshops	- 3-5 IWG Workshops (1 at LANL) - 1-2 papers submitted - 1-2 collaborative proposals submitted to NSF - Explore support sources to continue IWG activities
Activities Year 2	Deliverables/Milestones
- Solicit proposals for IWG Workshops - Select 3 proposals through peer-review process, coordinate with LANL for fourth Workshop, "Bridging Disciplines and Bridging Scales", coordinate with Nevada and Idaho EPSCoR for fifth (tri-state) workshop, "Regional EPSCoR Workshop: Addressing Climate Change Research and Education Challenges in the Western United States" - Hold Workshops	- 5 IWG Workshops (1 at LANL, 1 tri-state Workshop) - 2-5 papers submitted - 1-2 collaborative proposals submitted to NSF - Explore support sources to continue IWG activities

- Develop plans to write synthesis papers - Develop plans to submit NSF cross-cutting program proposals - Perform evaluation and assessment of Workshops	
Activities Year 3	Deliverables/Milestones
- Solicit proposals for IWG Workshops - Select 4 proposals through peer-review process, coordinate with LANL for fifth Workshop, "Bridging Disciplines and Bridging Scales" - Hold Workshops - Develop plans to write synthesis papers - Develop plans to submit NSF cross-cutting program proposals - Perform evaluation and assessment of Workshops	- 5 IWG Workshops (1 at LANL) - 2-5 papers submitted - 1-2 collaborative proposals submitted to NSF - Submit proposal(s) to agencies and other funding sources to continue this effort
Activities Year 4	Deliverables/Milestones
- Solicit proposals for IWG Workshops, - Select 3 proposals through peer-review process, coordinate with LANL for fourth Workshop, "Bridging Disciplines and Bridging Scales", coordinate with Nevada and Idaho EPSCoR for fifth (tri-state) workshop, "Regional EPSCoR Workshop: Addressing Climate Change Research and Education Challenges in the Western United States", - Hold Workshops, - Develop plans to write synthesis papers, - Develop plans to submit NSF cross-cutting program proposals - Perform evaluation and assessment of Workshops	- 5 IWG Workshops (1 at LANL, 1 tri-state Workshop) - 2-5 papers submitted - 1-2 collaborative proposals submitted to NSF - Submit proposal(s) to agencies and other funding sources to continue this effort
Activities Year 5	Deliverables/Milestones
- Solicit proposals for IWG Workshops, - Select 4 proposals through peer-review process, coordinate with LANL for fifth Workshop, "Bridging Disciplines and Bridging Scales", hold Workshops, develop plans to write synthesis papers, - Hold Workshops, - Develop plans to write synthesis papers, - Develop plans to submit NSF cross-cutting program proposals - Perform evaluation and assessment of Workshops	- 5 IWG Workshops (1 at LANL) - 2-5 papers submitted - 1-2 collaborative proposals submitted to NSF - Submit proposal(s) to agencies and other funding sources to continue this effort

Resources Provided

- Resources provided relate to facilitating and convening groups of scientists in a venue that allows them to creatively collaborate.
- Funding is provided for lodging, travel and meals for 8-12 scientist/educator participants for each workshop.
- Funding is provided for meeting venue costs.

Efforts to Promote Sustainability

The EPSCoR State Office and the IWGs will explore opportunities to continue collaborative research efforts via support from NSF, LANL, Foundations, and other sources.

Summary and Changes in Planned Activities Since Proposal

The IWGs will be managed from the EPSCoR State Office. There are no changes to scope of work, activities or resources.

Activity 6: Critical Infrastructure Gap Seed Awards

Strategic Objective

The Critical Infrastructure Gap Seed Awards are designed to increase the impact of NM EPSCoR on the critical student population at NM's non-PhD granting institutions. Faculty at these colleges and regional universities will be able to apply for undergraduate institution infrastructure grants, which may be used to purchase research and teaching equipment related to climate change, hydrology, and water quality science, and to pay for student researcher salaries, research supplies, and student conference travel.

Activities Supported

- Seven Seed Awards will be supported by EPSCoR funds and will be available to faculty from the regional universities and tribal colleges.
- The undergraduate institution faculty will be asked to integrate their proposed activities with the Undergraduate Research Opportunities Program through recruitment and collaborations with research institution faculty.

Participants

Participants are the four regional Hispanic Serving Institutions - Eastern New Mexico University, Northern New Mexico College, Western New Mexico University and New Mexico Highlands University, and the three tribal colleges - Diné College, Southwestern Indian Polytechnic Institute, and Navajo Technical College. Mike Mullin at NMT; EPSCoR State Office.

Planned Actions and Deliverables by Year

Timeline of Planned Activities and Deliverables/Milestones by Year	
Activities Year 1	Deliverables/Milestones
- Develop proposal template - Develop RFP - Announce upcoming opportunity during Jr. Faculty Leadership Workshops and IWGs - Make contacts for UROP recruiting	- Seed Award proposal template - Seed Award RFP - Seed Award announcements at Jr. Faculty Leadership Workshops and IWGs - UROP recruiting at seven institutions
Activities Year 2	Deliverables/Milestones
- Announce RFP for Year 3 Seed Awards - Solicit proposals - Announce upcoming opportunity during Jr. Faculty Leadership Workshops and IWGs - Make contacts for UROP recruiting - Select two institutions for Year 3 Seed Awards	- RFP announcements distributed statewide and through Jr. Faculty Leadership Workshops and IWGs - Two institutions selected for Year 3 Award through peer-review process - UROP recruiting at seven institutions
Activities Year 3	Deliverables/Milestones
- Release Seed Awards to two institutions - Announce RFP for Year 4 - Solicit proposals - Announce opportunity during Jr. Faculty Leadership Workshops and IWGs - Make contacts for UROP recruiting - Select three institutions for Year 4 Seed Awards	- Seed Award issued to two institutions - RFP announcements distributed statewide and through Jr. Faculty Leadership Workshops and IWGs - Three institutions selected for Year 4 Award through peer-review process - UROP recruiting at seven institutions
Activities Year 4	Deliverables/Milestones
- Release Seed Awards to three institutions - Announce RFP for Year 5 - Solicit proposals - Announce opportunity during Jr. Faculty Leadership	- Seed Award issued to three institutions - RFP announcements distributed statewide and through Jr. Faculty Leadership Workshops and IWGs - Two institutions selected for Year 5 Award through

Workshops and IWGs - Make contacts for UROP recruiting - Select two institutions for Year 5 Seed Awards	peer-review process - UROP recruiting at seven institutions
Activities Year 4	Deliverables/Milestones
- Release Seed Awards to two institutions - Make contacts for UROP recruiting	- Seed Award issued to two institutions - UROP recruiting at seven institutions.

Resources Provided

Up to $50,000 per institution for research and teaching equipment related to climate change, hydrology, and water quality science, and to pay for student researcher salaries, research supplies, and student conference travel.

Efforts to Promote Sustainability

Management through the EPSCoR State Office and the UROP PI at NMT will explore opportunities to continue this effort via support from NSF (EPSCoR), Foundations, and other sources. A sustainability plan and template proposal will be developed in year 3, and proposal submission will begin in year 3 and continue through years 4 and 5.

Summary and Changes in Planned Activities Since Proposal

There are no changes in scope of work or planned activities.

Activity 7: Cyberinfrastructure

Strategic Objective

Enhance scientific data and model output generation, management, discovery, and use through cyberinfrastructure.

Activities Supported

- Development of a portal that provides a single point of access for RII 3 project products, services, and information related to water and climate change
- Development of interoperable data discovery and delivery mechanisms within the newly created portal. The portal will be based on open standards (OGC, FGDC/ISO, W3C) that facilitate data access, generation of derived products, and on-demand processing.
- Development of efficient data acquisition, processing, and storage models that enable streamlined management of data products acquired and generated by the project.
- Development of a model for the effective use of high performance computing through coordination with the New Mexico Computer Applications Center (NMCAC) via a half-time support and software consulting position that will be managed by the project CI team (see participants list below).
- Determination of user requirements from the project research and education teams, and external stakeholder communities (for example, water managers within the NM Office of State Engineer)
- Development of capabilities for interoperability with the CUAHSI Hydrologic Information System (HIS) (and potentially other existing hydrology data systems).
- Deployment of collaboration tools that facilitate knowledge exchange to all partner institutions.

Participants

Todd Ringler at LANL; Joe Galewsky, Timothy Thomas and Karl Benedict at UNM; John Wilson and Lorie Liebrock at NMT.

Planned Actions and Deliverables by Year

Timeline of Planned Activities and Deliverables and Milestones by Year	
Activities Year 1	Deliverables/Milestones
- Define data and metadata standards for project - Coordinate with science, education, and policy project partners in target system capabilities, products, services, and interfaces - Develop initial project and data portal - Integrate data portal services with NM Resource Geographic Information System (RGIS) for long-term and general access - Develop initial data/metadata ingest services - Develop service framework for early data products - Initiate HPC development efforts with NMCAC - Deploy collaboration tools in support of project - Integration of HPC Summer Institute training into tri-state HPC training model	- Reference documentation for adopted data and metadata format standards - Deploy data and project portal - Deploy hosted collaboration tools for online meetings - Deploy metadata creation tool and related data upload tool for manual addition of science data products into the project portal - Deliver initial framework data products through the project portal and RGIS - Deliver HPC training to tri-state participants
Activities Year 2	Deliverables/Milestones
- Coordinate data ingest with project science partners - Develop catalog services for enhanced discovery of project data products and services - Expand data and visualization services for project foundation data - Develop initial automated data ingest services for	- Expanded framework data products available through the project data access portal - Initial data ingest services for data acquisition systems - Initial deployment of catalog services for project data and services - Enhanced data and visualization services

ongoing data acquisition systems	- Enhanced portal capabilities and content
Activities Year 3	Deliverables/Milestones
- Coordinate data ingest with project science partners - Expand data and visualization services for project foundation data - Expand automated data ingest services for ongoing data acquisition systems - Cycle additional data storage capacity into the NM EPSCoR system	- Expanded data ingest services for new data acquisition systems as they come online - Enhanced data and visualization services - Enhanced catalog services for project data and services - Enhanced portal capabilities and content - Installation and use of increased storage capacity provided by replacement storage server
Activities Year 4	Deliverables/Milestones
- Coordinate data ingest with project science partners - Expand data and visualization services for project foundation data - Expand automated data ingest services for ongoing data acquisition systems - Cycle additional application delivery and processing capacity into the NM EPSCoR system	- Expanded data ingest services for new data acquisition systems as they come online - Enhanced data and visualization services - Enhanced catalog services for project data and services - Enhanced portal capabilities and content - Installation and use of increased application delivery capacity provided by replacement application servers
Activities Year 5	Deliverables/Milestones
- Coordinate data ingest with project science partners - Expand data and visualization services for project foundation data - Expand automated data ingest services for ongoing data acquisition systems - Cycle additional data storage capacity into the NM EPSCoR system - Migrate data ingest and processing services into RGIS for long-term continuity	- Expanded data ingest services for new data acquisition systems as they come online - Enhanced data and visualization services - Enhanced catalog services for project data and services - Enhanced portal capabilities and content - Installation and use of increased storage capacity provided by replacement storage server

Resources Provided

- Salary support for EDAC Director, senior web designer, web programmer/developer, and NMCAC HPC programmer.
- Materials and supplies include a dedicated collaboration tools server, replacement data servers and application servers for the original data storage servers, and software licensing.
- Travel is funded for research collaboration meetings.

Efforts to Promote Sustainability

Sustainability will be promoted by integration with New Mexico's Resource Geographic Information System, a cooperative program between UNM and the State of New Mexico. Continuous integration of new data and services into RGIS will proceed as they are added to the project. Complete migration of EPSCoR metadata and data ingest services into the RGIS framework will occur in Years 2 – 5.

Summary and Changes in Planned Activities Since Proposal

There are no changes in the overall scope of work. Delayed startup date effects later hiring of graduate students. NM EPSCoR has submitted an EPSCoR Track 2 Cyberinfrastructure proposal. If these funds are awarded, planned activities will involve coordination with the Western Consortium partner states, Nevada and Idaho. Implementation will include collaborative cross-state activities for data sharing and integration.

Activity 8: Diversity

Strategic Objective

NM EPSCoR will actively seek out and welcome people with diverse backgrounds to join our multidisciplinary, multicultural, and multigenerational team in an inclusive environment where ideas are freely exchanged, cultures and traditions are respected, and personal and professional growth is encouraged. More specific objectives include:

- Significant involvement of people with diverse backgrounds and underrepresented groups throughout the five-year project and within the individual components of the project.
- Increase the research capacity of non-PhD granting institutions in order to increase the involvement of underrepresented groups and women faculty and students.
- Increase and improve the quality of STEM education in K-12 schools in rural areas and on tribal lands.
- Support professional development in terms of diversity training for teachers in STEM disciplines and university/college faculty.
- Increase the number of incoming students into STEM disciplines from underrepresented groups.
- Increase cultural sensitivity and awareness at research institutions and with all EPSCoR project personnel.
- Develop appropriate protocols for accessing tribal and culturally sensitive lands for research.
- Utilize one IWG per year to monitor diversity goals and advise programs on diversity issues.

Activities Supported

Formal education and public outreach

- K-12 Teacher Institute targets teachers in rural communities located near stream sensor networks.
- UROP recruits URM students from regional and tribal non-PhD granting academic institutions.
- Graduate Research Training group engages URM graduate students and project scientists.
- Junior Faculty Leadership Workshop provides a diversity training component.
- Science Cafes are hosted in rural Hispanic or Native American communities.

Research

- UROP recruits URM students to work with faculty.
- Research faculty actively engaged in K-12 education and public outreach.
- Seed grant program for non-PhD granting institutions increases research capacity.
- One IWG per year has a diversity component and/or is focused on diversity as a comprehensive topic.
- Sensor networks are monitored by teachers from K-12 programs in rural schools and on tribal lands.

Cyberinfrastructure

- Website development for public access to project data including Spanish language links where appropriate.
- Support solutions to broadband connectivity issues in rural New Mexico.

Participants

Marnie Carroll at Dine College; Edward Martinez at NMHU; Mike Pullin at NMT; and Clyde Romero at the NM EPSCoR State Office.

Planned Actions and Deliverables by Year

Timeline of Planned Activities and Deliverables/Milestones by Year	
Activities Year 1	Deliverables/Milestones
- Organize template and methods for annual report to include diversity progress report - Develop communication coordination with project evaluator - Formalize specific contacts for diversity issues in each discipline (hydrology, cyberinfrastructure,	- Track and publish demographics with respect to diversity - 1 IWG includes a focus on diversity issues

cyberinfrastructure, NMMNHS, climate modeling, water quality) - Pursue additional funding to support the bridge between K-12 and research - Develop and host first IWG on diversity issues	
Activities Year 2	Deliverables/Milestones
- Evaluate outcomes from first UROP and recommend changes to improve diversity - Review locations of K-12 outreach for success in diversity - Pursue additional funding as needed - Develop and host second IWG on diversity issues and evaluate prior year and recommend changes and strategies to meet diversity goals	- Track and publish demographics with respect to diversity - 1 IWG includes a focus on diversity issues - 1-2 proposals submitted for additional funding for diversity initiatives
Activities Year 3	Deliverables/Milestones
- Support non PhD granting institutions to submit seed grants for research infrastructure - Publications on EPSCoR education and diversity for all components (not necessarily peer reviewed) - Develop and host third IWG on diversity issues and evaluate prior year and recommend changes and strategies to meet diversity goals	- Track and publish demographics with respect to diversity - 1 IWG includes a focus on diversity issues - 1-2 proposals submitted for additional funding for diversity initiatives - 1 publication on EPSCoR education/diversity-related topics (not peer-reviewed journal)
Activities Year 4	Deliverables/Milestones
- Develop and host fourth IWG on diversity issues and evaluate prior year and recommend changes and strategies to meet diversity goals	- Track and publish demographics with respect to diversity - 1 IWG includes a focus on diversity issues - 1-2 proposals submitted for additional funding for diversity initiatives - 1 publication on EPSCoR education/diversity-related topics (not peer-reviewed journal)
Activities Year 5	Deliverables/Milestones
- Develop and host fifth IWG on diversity issues and evaluate prior year and recommend changes and strategies to meet diversity goals	- Track and publish demographics with respect to diversity - 1 IWG includes a focus on diversity issues - 1-2 proposals submitted for additional funding for diversity initiatives - 1 publication on EPSCoR education/diversity-related topics (not peer-reviewed journal)

Resources Provided

- Full time salary support for a new position located at the NM EPSCoR State Office, Program Manager of Diversity and Education.
- Program support for activities designed to enhance diversity as listed under 'Activities Supported'.
- One IWG per year will include or focus on some aspect to enhance diversity, for example, the increased involvement of tribal colleges in climate change research.

Efforts to Promote Sustainability

Efforts to promote sustainable increases in diversity will center on building strong collaborations among faculty at the tribal colleges, regional HSIs and major research institutions. Identifying and focusing on diversity across all of the human infrastructure components will help in establishing a pipeline from K-12 programs, through the undergraduate UROP program, and on to graduate research activities.

Summary and Changes in Planned Activities Since Proposal

The diversity planning group will form the foundation for a new formally-established Diversity Committee. The Diversity Committee will meet in person or by teleconference every four to six months and convene in person at the annual meeting. The Diversity Committee will meet with the EPSCoR Project Evaluator and establish a working relationship regarding diversity metrics.

Activity 9: K-12 Professional Teacher Development

Strategic Objective

Enhance professional development of middle school teachers in northern NM. Objective is to improve their teaching ability in STEM areas, particularly on the science subject of climate change and water resources.

Activities Supported

Teams of middle school teachers will participate in a three-day Summer Institute during which project scientists will engage the teachers in field experiments such as equipment deployment and data collection. The Earth's Birthday Project will lead the teachers through a set of climate change related modules to take back to their classrooms. Earth's Birthday Project, founded in 1989 and largely funded through non-profit conservation organizations such as The Nature Conservancy and World Wildlife Fund, creates and disseminates hands-on classroom science materials to elementary and middle school teachers. The teachers will return for two weekend workshops, one in the spring and one in the fall. The weekend workshops will strengthen the bonds within the teacher teams, provide updates and expand the scientific content delivered during the summer, and allow the teachers to share best practices for science teaching. NM EPSCoR education faculty, the Earth's Birthday project and retired NM scientists, mathematicians, and engineers will provide mentoring and support during the school year.

Participants

Clyde Romero; Mary Jo Daniel at NM Public Education Department

Planned Actions and Deliverables by Year

Timeline of Planned Activities and Deliverables/Milestones by Year	
Activities Year 1	Deliverables/Milestones
- Teacher Summer Institute	- 21 teachers attend Summer Institute - Teachers provide reports on classroom implementation and activities
Activities Year 2	Deliverables/Milestones
- Fall workshop, spring workshop, Summer Institute	- 21 teachers attend fall workshop, spring workshop, Summer Institute - Teachers provide reports on classroom implementation and activities
Activities Year 3	Deliverables/Milestones
- Fall workshop, spring workshop, Summer Institute	- 21 teachers attend fall workshop, spring workshop, Summer Institute - Teachers provide reports on classroom implementation and activities
Activities Year 4	Deliverables/Milestones
- Fall workshop, spring workshop, Summer Institute	- 21 teachers attend fall workshop, spring workshop, Summer Institute - Teachers provide reports on classroom implementation and activities
Activities Year 5	Deliverables/Milestones
- Fall workshop, spring workshop	- 21 teachers attend fall workshop, spring workshop - Teachers provide reports on classroom implementation and activities

Resources Provided

- Stipends, travel, housing, subsistence for 21 teachers per year.

- Tuition credit for teachers in the summer institute who choose to apply the institute to formal education degree programs.
- Travel mileage and per diem for travel to Institute and workshops for faculty and scientists.
- Honoraria for program leaders and faculty.
- Funds for teacher materials and supplies.
- Funds for publication and recruiting.

Efforts to Promote Sustainability:
Sustainability will be promoted through application for additional funding from non-NSF sources and through collaboration with the State of New Mexico Public Education Department.

Summary and Changes in Planned Activities Since Proposal
There are no changes from the original proposal.

Activity 10: Undergraduate Research Opportunity Program

Strategic Objective

Increase the exposure of students at non-PhD granting institutions in NM to high quality, relevant, hypothesis-driven research.

Activities Supported

Undergraduates, recruited from institutions serving large populations of Hispanic and Native American students, will engage in four to nine weeks of summer research. Because the participants may not have sufficient preparation, the program will begin at NMT with a week of workshops and short courses on climate change, hydrology, and water quality, which will be taught by EPSCoR-supported faculty using a mixture of classroom, laboratory, and field experiences. After completing the introductory coursework, participants will be placed with research mentors for the remainder of the program. The program will conclude with a statewide summer undergraduate environmental research conference at the Preserve where students from UROP, the NMT REU program, and other summer environmental research endeavors within the state will be invited to present the results of their research to an audience of students, faculty, and research staff.

Participants

Mike Pullin at NMT; Bob Parmenter at VCNP; NM EPSCoR research scientists

Planned Actions and Deliverables by Year

Timeline of Planned Activities and Deliverables/Milestones by Year	
Activities Year 1	Deliverables/Milestones
- 9 week UROP	- 10-14 students attend UROP
Activities Year 2	Deliverables/Milestones
- 9 week UROP	- 10-14 students attend UROP
Activities Year 3	Deliverables/Milestones
- 9 week UROP	- 10-14 students attend UROP
Activities Year 4	Deliverables/Milestones
- 9 week UROP	- 10-14 students attend UROP
Activities Year 5	Deliverables/Milestones
- 9 week UROP	- 10-14 students attend UROP

Resources Provided

- One month of summer support for M. Pullin.
- Two months of summer support for a program manager.
- Stipends, travel, housing, subsistence for 10-14 students per year.
- Honoraria for program leaders and faculty.
- Funds for field vehicle mileage, student research materials and supplies, and for publication and recruiting.

Efforts to Promote Sustainability

Sustainability will be promoted by assisting the regional and tribal colleges to develop UROPs for their institutions.

Activity 11: Graduate Research Training Group

Strategic Objective

The objectives of this activity are three-fold: (1) to promote transdisciplinary linkages across climatology, hydrology, and the socioeconomic sciences; (2) to create a cadre of scientists that are well-versed in the modeling tools and underlying frameworks used in the three scientific domains; and (3) to engage MS and PhD students and faculty from all degree granting institutions in the state as well as scientists from the national laboratories.

Activities Supported

- Climate Change Graduate Seminar Course will be hosted at the LANL Institute for Advanced Studies (IAS) and broadcast to NM universities. The seminar course will be offered annually and will include EPSCoR scientists and recognized experts from within and outside the state that are engaged in climate, hydrology and socioeconomic studies related to climate change.
- A Graduate Summer School in Regional Climate Modeling will be offered during two summers; at this time anticipate offering the course in Year 2 and Year 3. The innovative school will include extensive hands-on training in running relevant climate, hydrologic, and economic models.

Participants

Todd Ringler at LANL; Laura Crossey at UNM; other NM EPSCoR research programs graduate students.

Planned Actions and Deliverables by Year

Timeline of Planned Activities and Deliverables/Milestones by Year	
Activities Year 1	Deliverables/Milestones
Plan Climate Change Graduate Seminar Course and other graduate student training opportunities	
Activities Year 2	Deliverables/Milestones
Refine Climate Change Graduate Seminar Course Broadcast seminar course to NM Institutions Develop Graduate Summer School curriculum Invite faculty and instructors Hold Summer School Perform evaluation and assessment of Summer School	Broadcast of seminar course 10 graduate students participate in Summer School
Activities Year 3	Deliverables/Milestones
Refine Climate Change Graduate Seminar Course Broadcast seminar course to NM Institutions Develop Graduate Summer School curriculum Invite faculty and instructors Hold Summer School Perform evaluation and assessment of Summer School	Broadcast of seminar course 10 graduate students participate in Summer School
Activities Year 4	Deliverables/Milestones
Refine Climate Change Graduate Seminar Course Broadcast seminar course to NM Institutions	Broadcast of seminar course
Activities Year 5	Deliverables/Milestones
Refine Climate Change Graduate Seminar Course Broadcast seminar course to NM Institutions.	Broadcast of seminar course

Resources Provided

- General and broadcast facilities at LANL Institute for Advanced Studies (IAS).
- Lodging, travel and meals for 10 graduate students.

- Lodging, travel, per diem, and honoraria for instructors.
- Course materials for students.

Efforts to Promote Sustainability:
Explore opportunities to continue this effort via support from NSF, LANL, Foundations, and other sources. In Year 3, develop a sustainability plan and template proposal. Submit proposal(s) to LANL and other funding sources to continue this effort in Years 4 and 5.

Summary and Changes in Planned Activities Since Proposal
There are no changes from the original proposal.

Activity 12: NSF Days

Strategic Objective
Inform faculty throughout NM about funding opportunities via NSF Days

Activities Supported:
In collaboration with the National Science Foundation, NSF Days, a day and a half to two-day workshop will be held during Year 2 of the project. Program Directors from all NSF Directorates will be invited to meet with faculty from colleges and universities to discuss relevant funding opportunities and strategies for seeking funding from Foundation-wide and cross-cutting programs.

- We will hold an additional half-day workshop specifically designed for 2-year colleges and tribal colleges and hosted at Central New Mexico College.
- We will determine whether to hold the annual tri-state conference in conjunction with NSF Days.

Participants
NM EPSCoR State Office; Kirk Minnick at Minnick & Associates; faculty and staff from colleges and universities in NM and the surrounding states.

Planned Actions and Deliverables by Year

Timeline of Planned Activities and Deliverables/Milestones by Year	
Activities Year 1	Deliverables/Milestones
Contact NSF to start planning NSF will determine the date, agenda and presenters Reserve event space	NSF contacted and event space reserved
Activities Year 2	Deliverables/Milestones
In collaboration with NSF, plan event Advertise, implement, perform evaluation and assessment	250 participants attend event
Activities Year 3	Deliverables/Milestones
Track proposal submission and funding success	
Activities Year 4	Deliverables/Milestones
Track proposal submission and funding success	
Activities Year 5	Deliverables/Milestones
Track proposal submission and funding success	

Resources Provided

- Lodging and travel for faculty and staff.
- Event fees such as room rental and food.
- NSF provides all handouts; NSF covers costs for all NSF presenters.

Efforts to Promote Sustainability
Explore opportunities to continue promotion of NSF funding opportunities via support from NSF EPSCoR outreach visits.

Summary and Changes from Proposal
Funding for this event ($10K) was moved from participant support in the Year 2 in the New Mexico Museum of Natural History subaward budget to the Year 2 UNM management budget.

Activity 13: Faculty Leadership Fellowship Program

Strategic Objective
Training for early-career faculty to enhance competitiveness and leadership skills.

Activities Supported
Competitiveness and leadership skills are enhanced through professional development activities related to communication (i.e., policy-makers, public, media), successful proposal development, project management, program evaluation and assessment, academic and research cyberinfrastructure, education outreach and diversity awareness, and networking with faculty from throughout the state. Activities include lectures and informal discussions, hands-on activities, exercises, and field trips.

Participants
NM EPSCoR State Office; Kirk Minnick at Minnick & Associates; and guest lecturers and instructors supported through honoraria.

Planned Actions and Deliverables by Year

Timeline of Planned Activities and Deliverables/Milestones by Year	
Activities Year 1	Deliverables/Milestones
- Develop curriculum and invite faculty and instructors - Hold Workshop - Perform evaluation and assessment of Workshop	- 16-20 Fellows participate in Workshop
Activities Year 2	Deliverables/Milestones
- Develop curriculum and invite faculty and instructors - Hold Workshop - Perform evaluation and assessment of Workshop	- 16-20 Fellows participate in Workshop
Activities Year 3	Deliverables/Milestones
- Develop curriculum and invite faculty and instructors - Hold Workshop - Perform evaluation and assessment of Workshop	- 16-20 Fellows participate in Workshop
Activities Year 4	Deliverables/Milestones
- Develop curriculum and invite faculty and instructors - Hold Workshop - Perform evaluation and assessment of Workshop	- 16-20 Fellows participate in Workshop
Activities Year 5	Deliverables/Milestones
- Develop curriculum and invite faculty and instructors - Hold Workshop - Perform evaluation and assessment of Workshop	- 16-20 Fellows participate in Workshop

Resources Provided
- Lodging, travel and meals for 20 faculty fellows.
- Lodging, travel, per diem, and honoraria for instructors.
- Course materials for students including books.

Efforts to Promote Sustainability
Explore opportunities to continue this effort via support from NSF (EPSCoR, EHR), Foundations, and other sources. Develop sustainability plan and template proposal in Year 3. Submit proposal(s) to Higher Education Department and other funding sources to continue this effort.

Activity 14: Public Outreach and Communication

Strategic Objective
Create a citizenry that is informed about climate change and its impact on NM's natural resources.

Activities Supported
This objective will be achieved via five specific programs that will be coordinated and delivered through the Education Department at the New Mexico Museum of Natural History and Science (NMMNHS): a Climate Change Exhibit, a statewide Seminar Series, community-based Science Cafés, a Town Hall, and a Climate Change Web Portal.

Participants
Jessica Sapunar-Jursich, Project Coordinator, Guest Curator, and Informal Science Evaluator at NMMNHS; Karl Benedict a UNM.

Planned Actions and Deliverables by Year

Timeline of Planned Activities and Deliverables/Milestones by Year	
Activities Year 1	Deliverables/Milestones
- Climate Change Exhibit Planning - Build advisory team composed of NM EPSCoR scientists and other content specialists - Hire evaluator and conduct upfront visitor assessment through interviews/surveys - Plan exhibit location, layout, design, and content - Purchase equipment for exhibit - Advertise, hire, and train Project Coordinator	- Completed evaluation document, planning document, and equipment purchasing for the Climate Change Exhibit - Project Coordinator established in position
- Science Cafés Planning - Determine communities to be served in rural, Northern NM - Form collaborations with organizations to be partnered with in those communities including Teacher Summer Institute participants and UROP - Select speakers for presentations - Develop hands-on activities to accompany program	- Completed Science Café planning document, including letters of commitment from partners
- Seminar Series Planning and Execution - Research and plan venue locations in Los Alamos/Santa Fe, Albuquerque, Socorro, and Las Cruces - Form collaborations with partnering venue locations and LANL and SNL - Research and plan for marketing of events - Offer one lecture in each city, as feasible	- 1 Seminar Series - 40 participants per seminar
Activities Year 2	Deliverables/Milestones
- Climate Change Exhibit fabrication - Open exhibit in Spring 2010	- Exhibit/Museum attendees: 80,000-100,000 per year
- Science Cafés hold 1 event	- Science Café: 5 participants per café
- Seminar Series hold 3 events	- Seminar Series: 40 participants per seminar
Activities Year 3	Deliverables/Milestones
- Climate Change Exhibit on going	- Exhibit/Museum attendees: 80,000-100,000 per year

- Science Cafés hold 2 events	- Science Café: 5 participants per café
- Seminar Series hold 3 events	- Seminar Series: 40 participants per seminar
Activities Year 4	Deliverables/Milestones
- Science Cafés hold 2 events	- Science Café: 5 participants per café
- Seminar Series hold 3 events	- Seminar Series: 40 participants per seminar
- New Mexico Town Hall hold 1 event	- Town Hall: 75 – 100 people
Activities Year 5	Deliverables/Milestones
- Science Cafés hold 2 events	- Science Café: 5 participants per café
- Seminar Series hold 3 events	- Seminar Series: 40 participants per seminar

Resources Provided:

- Salary support for a project coordinator and a science consultant at NMMNHS, an exhibit evaluator, and a contractor for setting up the Science on a Sphere exhibit.
- Equipment funds to obtain the Science on a Sphere exhibit.
- Materials and supplies for the development of seven Science Cafes, twelve Science Seminars, and one Town Hall.

Efforts to Promote Sustainability

The Climate Change Exhibit, including the Science on a Sphere, will be maintained and all costs assumed by the NMMNHS. Ongoing Science Cafes and Seminar Series will be supported by Museum through both foundation funding and external grants.

Summary and Changes in Planned Activities Since Proposal

There are no changes from the original proposal.