Water Distribution Vulnerability - Fire Hydrants

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Presentation Abstract 1

This presentation will clearly illustrate a real world vulnerability to water distribution systems which is not taught in the classrooms or for obtaining professional certifications.

Content covers basic infrastructure of a water distribution system, identifying current vulnerabilities and current security measures used within those systems. Congressional requirements and suggested timelines useful for identifying and mitigating those vulnerabilities will be considered. Credible international and domestic threats to water systems will be provided. We will focus on the vulnerability to the distribution system via the fire hydrant with and without a pump. Documentation from the US Army Corps of Engineers will be shown to indicate how quickly and efficiently a small amount of an accessible substance, pumped into a fire hydrant can contaminate an entire water distribution system. Plus, the actions currently being considered and tested by the Army Corps of Engineers to mitigate the vulnerability at their facilities will be reviewed. The American Water Works Association (AWWA) legal liability statement will show participants how a lack of action could be a liability. Additionally, information on contaminants and concentrations rates for accidental and intentional contamination of water system will be detailed to dispel myths. Finally, solutions and action plans will be provided to share with municipalities, water companies, engineers and industry leader for mitigation of the vulnerability.

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Shortage in the Midst of Abundance

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Presentation Abstract 2

As measured by precipitation per acre, New Mexico is the fifth driest state in the lower 48 states. But measured as precipitation per capita, we are in the upper quartile with about 50 acre feet of precipitation per capita. An estimated two billion acre-feet of moisture passes over New Mexico in a typical year. Only about 6% of this moisture is converted into precipitation naturally and this percentage could be increased. From this 6%, only about 3.5% becomes available for beneficial use; a low rate of capture which could be substantially increased. Agriculture accounts for almost 85% of beneficial use but only about half the water is actually utilized by the crop and this efficiency could be substantially increased. We have billions of acre feet of deep water resources which we are reluctant to allow to be developed and byproduct water from oil and gas operations which we decline to utilize.

This raises the question of why a State which has such enormous water resources is in a permanent state of water shortage. Reasons include quirks in our river compacts that complicate the development of water resources, institutional arrangements that complicate implementing sound water policies, water policies that discourage both conservation and the development of water resources, and support by various stakeholders for policies that keep water scarce. These reasons will be discussed in detail and suggestions provided on how to change the current situation and achieve long-term sustainability.

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A Database of New Mexico Water Rights Prices

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Presentation Abstract 3

The transfer of water rights is an important method used for stretching available water supplies to meet new water demands. In the Lower Rio Grande Basin it is used to support sustained population and economic growth. Potential sellers are unsure of what price to charge for a water right, while buyers are unsure of what price to pay. This lack of information on water right prices creates an uncertain and unpredictable market, which makes it more difficult to transfer water rights to meet growing demands. Improved understanding of the economic forces influencing water right prices will help buyers and sellers, while adding vital information to support continued economic development of the region. Starting in the Lower Rio Grande Basin (LRG), this project has assembled actual verified water rights market data into a database that can be used to characterize the price of water rights. The database will include data from 1980 to present. The database and models derived from it will support a better understanding of the economic and hydrologic forces affecting the demand, supply, and price of water. This will act as the basis for a possible future economic model for the basin. The model will be used to explain factors affecting water rights prices for the Lower Rio Grande Basin. With the success of the LRG model, the same process can be applied to other basins in New Mexico where similar development pressures increase the demands for scarce water.

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Chemical Fingerprint of Surface-Runoff on Groundwater Recharge in the Arid Regions

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Presentation Abstract 4

Studies of Amargosa Desert regional groundwater indicate that infiltration of surface runoff occurs in the arroyos subsequent to runoff producing storms and that this infiltration represents a large portion of the groundwater recharge. Accurate estimates of groundwater recharge are necessary to understanding the long-term sustainability of groundwater resources and predictions of groundwater flow rates and directions. As an arid region, the surface runoff water could be a major source of groundwater recharge and then the powerful transporter of the contaminants to the vadose zone. The present study explains the design and emplacement of 38 surface runoff samplers at 19 different locations in the Amargosa Desert region to provide a new insight into the chemical evolution of southern Nevada's groundwater and its potential flow paths and rates during the infiltration and surface runoff processes, through initiating a surface runoff sampling network to track the chemical fingerprint of the surface runoff water on the groundwater recharging and infiltration chemistry, by collecting a baseline data on a comprehensive suite of chemical parameters, which will include the major ion chemistry, nutrients, trace elements, as well as the stable isotope ratios and the resources available at The Nye County Nuclear Waste Repository Project Office (NWRPO).

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Improving Irrigation System Performance in the Middle Rio Grande by Utilizing a Decision Support System, SCADA, and a Public Outreach Program

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Presentation Abstract 5

The Rio Grande is one of the few large rivers in the American Southwest and supports a diverse and unique ecosystem as well as urban, industrial, interstate, and agricultural water demands. Competition for this limited water resource has increased tremendously during the last decade and many complex issues have arisen as environmental concerns warrant a larger portion of available water. Irrigation water has historically been delivered using an on-demand system, but the farm water deliveries are not metered and the agricultural water rights are not well defined and adjudicated.

Scheduled water delivery (SWD) provides the opportunity to increase overall irrigation system performance and define legitimate water use without adjudication. In SWD, lateral canals receive water from the main canal according to their need as defined by crop water requirements. A well-managed program of scheduled water delivery is able to fulfill seasonal crop water requirements in a timely manner, but requires less water than an on-demand water delivery. In order to successfully realize SWD in an irrigation district, several components need to be addressed and developed simultaneously.

This paper will present results of and on-going research in the Middle Rio Grande Conservancy District (MRGCD) related to implementation of scheduled water delivery supported by decision-support system and modernization of irrigation infrastructure. A Decision Support System (DSS) is a logical arrangement and analysis of available data to determine an optimal irrigation schedule for an irrigation system. A DSS developed over the last four years uses linear programming to find an optimum water delivery schedule for all canal service areas in MRGCD irrigation system. The DSS has been developed for all four division of the MRGCD and a significant validation effort of input parameters and model logic has been completed.

The second component for implementing scheduled water delivery is a program of irrigation infrastructure modernization with Supervisory Control and Data Acquisition (SCADA) system. The aging canal infrastructure of the MRGCD did not lend itself to accurate water measurement and regulation. Over the past six years, the MRGCD has modernized the canal infrastructure and developed a SCADA system with the focus being to improve water use efficiency. With structural modernization and SCADA, the irrigation system currently lends itself to the implementation of water delivery scheduling.

The third component in implementing scheduled water delivery is its acceptance by all water users as a matter of district policy and practice. To gain acceptance and disseminate information regarding SWD, a public outreach program was formulated that includes providing information to water users through newsletters, websites, and public meetings. It also includes training related MRGCD staff in the concepts and practice of scheduled water delivery and the use of related decision-support systems.

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Seasonal Streamflow Forecasting in the Rio Grande Basin Using Partial Least Squares Regression

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Presentation Abstract 6

The application of partial least squares regression (PLSR) in seasonal streamflow forecasting was investigated using snow water equivalent, precipitation, temperature from snow telemetry (SNOTEL) sites and previous flow conditions as input variables. The forecast performance of PLSR models was compared to principal components regression (PCR) models as well as to the Natural Resources Conservation Service (NRCS) official forecasts in three Rio Grande watersheds including Rio Grande Headwater Basin, Conejos River Basin in Colorado, and Rio Grande Basin above Elephant Butte Reservoir, New Mexico. The results indicated that using a precipitation index is a relatively effective method in both improving forecast accuracy and developing parsimonious regression models with fewer input variables. In comparison of PLSR and PCR, similar forecast accuracies were obtained for both methods in jackknife cross validation and the test period (2003-2007) although PLSR has higher calibration coefficient of determination and can reach its minimal prediction error with a smaller number of components than PCR. The comparison with NRCS official forecasts showed that the application of PLSR in seasonal streamflow forecasting is promising. This approach could be combined into NRCS's operational forecasting environment for possible forecast improvement.

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Effect of Municipal Wastewater Effluent on Arsenic Sorption to Desert Soils

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Presentation Abstract 7

Chronic low-level exposure to arsenic has been found to increase health risks. In January 2006, the Environmental Protection Agency lowered the maximum contaminant level for arsenic in drinking water to 10 parts per billion (ppb). This affected many communities, and forced them to develop procedures for lowering arsenic in their drinking water. Disposal of arsenic residuals is a problem that must be considered when developing such a procedure. A simple and low cost solution is to land apply the arsenic concentrates with the municipal wastewater effluent. To insure the efficacy of this disposal method, experiments were performed to assess arsenic sorption parameters when arsenic is added to soil as part of the wastewater stream. In this study, the sorption of arsenate [As(V)] on three NM soils was measured in the presence and absence of wastewater effluent. Kinetic batch experiments were carried out on three diverse soils (sandy loam, clay loam and clay) collected from a land application facility in southern New Mexico. Arsenate solutions were equilibrated with the soils for 2 to 504 h. The presence of wastewater effluent dramatically decreased the retention of As(V) on all soils at all reaction times. The Freundlich K values were consistently lower for As(V) in effluent. Kinetic studies showed that for all three soils, initial As concentration affected the percent As sorbed when applied in buffer, with the highest percentages being at the lowest concentrations. In stark contrast, when A(V) is applied in effluent the percent As sorbed remains low for all initial concentration on all three soils. Thus, it appears that while soil is typically an effective sorbent for As(V) in 'clean' aqueous solutions, when the contaminant is added with wastewater effluent the sorption capacity of the soil is decreased. This work has important implications for land application practices and soil monitoring.

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Use of Temperature Time Series Data to Characterize River Leakage from the Rio Grande through Albuquerque, New Mexico

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Presentation Abstract 8

Paired transects of piezometers were installed at five locations in the Rio Grande riparian area, Albuquerque, New Mexico, to quantify the spatial variability of river leakage to the underlying alluvial aquifer. At each transect, continuous groundwater levels and temperatures were recorded, and the rate of horizontal-groundwater flow was quantified using two methods: Darcy's law and the Suzuki-Stallman equation. The Suzuki-Stallman equation for heat transport in an aquifer relies solely on ground water-temperature data, and thus provided an independent assessment of the groundwater flux rates calculated using Darcy's law. Calculations of median one-dimensional horizontal groundwater flow ranged from 0.1 to 0.5 ft/day. Results from the two methods agree, although the estimates from the Suzuki-Stallman method are slightly larger than those estimated using Darcy's Law.

Monthly groundwater temperature profiles, measured at 5-ft intervals in select piezometers during the nonirrigation season (November through February), were used to constrain the depth of the aquifer influenced by leakage from the river. Temperatures varied greatest at depths of less than 30 ft and ranged from 40˚F to 70˚F. Two general shapes of temperature envelope were observed. One shape indicated seasonal temperature extinction depths between 20 and 30 ft during the nonirrigation season. The second shape, exhibited nonirrigation-season temperature extinction at depths below the bottoms of the piezometers. Volumetric discharge through the riparian zone was calculated using the temperature-extinction depth as the base of the aquifer.

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URGWOM Simulations for the Middle Rio Grande Endangered Species Collaborative Program

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Presentation Abstract 9

Operations for reservoir and conveyance facilities in the Rio Grande basin from the Colorado-New Mexico state-line to below Elephant Butte reservoir, including the Rio Chama, are modeled using the Upper Rio Grande Water Operations Model (URGWOM). URGWOM simulates the physical processes describing flows in the river basin coupled with prioritized operational policies, or rules, that govern how and when water is moved in response to various laws, treaties, contracts, and agreements. Accounts for native and imported water track flows through various points in the basin. URGWOM is used by several work groups of the Middle Rio Grande Endangered Species Collaborative Program (Collaborative Program) to evaluate potential alternatives to meeting ecological needs of the listed species while accommodating growing demands for water. The work groups worked together with the URGWOM Technical Team to incorporate changes to coded rules for water management operations and on refining assumptions for key physical processes in the basin. URGWOM was used to simulate changes in water operations and other proposed actions under varying hydrologic conditions and to evaluate resulting impacts on river flows, river drying, water deliveries, and the overall water supply. Water operations evaluated included water leases, emergency storage agreements, changes in reservoir storage policies, and availability of system storage to meet the water needs for compliance with the 2003 Biological Opinion.

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Four Years of Nutrient Monitoring Along the Rio Ruidoso

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Presentation Abstract 10

The findings of the four-year long Rio Ruidoso Water Quality Monitoring Program are presented. The Rio Ruidoso was sampled at 18 locations throughout more than 34 miles of its reach and tributaries, from near its headwaters at the Mescalero-Apache reservation boundary (at Ski Apache) to downstream at approximately Glencoe, NM. Water quality information including stream nutrients (phosphorous, nitrogen, etc.), conductivity, temperature, turbidity and others, were obtained monthly at each location from April 2003 to March 2007. In addition, stream velocity and water depth measurements were also collected at these same locations, and river flow rates computed. In all, a total of approximately 20,000 data points were obtained during the monitoring program. Rio Ruidoso and tributary water quality and stream flow rates were presented on more than 700 graphs, with selected graphics included in this presentation. Results of the data indicated that the mean mass phosphorous loading along the Rio Ruidoso ranges from about 5 pounds per day (lbs/day) above the wastewater treatment plant outfall to around 40-lbs/day just below the outfall. The mean flow rate of the Rio Ruidoso was about 17 cubic feet per second (cfs), which is almost 11 million gallons per day (mgd), Algal growth occurred at times throughout almost the entire Rio Ruidoso. There was some correlation between algal growth and phosphorous levels. Photographs of the Rio Ruidoso during specific sampling periods are also presented.

The influx of nutrients into the Rio Ruidoso and its tributaries may be from both point and non-point sources.

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The Upper Rio Grande Simulation Model (URGSIM)

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Presentation Abstract 11

The Upper Rio Grande Water Operations Model (URWOM) is a suite of tools developed cooperatively by water management agencies in New Mexico to better understand, predict, plan, and account for surface water movement through the Rio Grande system in New Mexico. A complementary, monthly timestep model has been developed by Sandia National Laboratories in cooperation with the URGWOM technical team to provide a means for rapid screening of water management alternatives to identify leading candidates for further analysis with the daily timestep URGWOM model. The Upper Rio Grande Simulation Model (URGSIM) also provides an interactive modeling environment for educating the interested public and engaging stakeholders in water management decisions. This monthly timestep decision support simulation tool is built in Powersim Studio 2005 based on surface water dynamics and reservoir operations from URGWOM, groundwater dynamics from three MODFLOW regional groundwater flow models (Espanola Basin, Albuquerque Basin, and Socorro Basin), and atmospheric demand from the United States Bureau of Reclamation's ETToolbox. Future human demands are based on historic water use and population growth trends modifiable by the model user. URGSIM has an easy to use graphic user interface, and runs 40 year scenarios in tens of seconds.

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GIS-based Approach for Discriminating Evapotranspiration Among Land Cover Types in Southern New Mexico from ASTER Data

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Presentation Abstract 12

Modeling spatial variation of evapotranspiration (ET) over heterogeneous landscapes is a difficult task for hydrologists, agronomists, and meteorologists. The application of energy balance algorithms to remotely sensed imagery often fails in properly discriminating ET over spectrally diverse land covers for the complexity of modeling the surface roughness. Furthermore, the assumption of a horizontally homogeneous Lambertian surface reflecting energy equally in all directions affects the albedo and vegetation index calculations. The objective of this study is to improve the accuracy of the Surface Energy Balance Algorithm for Land (SEBAL) for estimating ET from ASTER datasets by analyzing the spatial variation of anisotropic reflectance and surface roughness among different plant species-dominated grasslands, shrublands, and dunelands in Southern New Mexico. The degree to which land cover surfaces are anisotropic is assessed by applying a wavelength-dependent non-Lambertian topographic transformation with the Minnaert function. Surface roughness is modeled using a land cover map in conjunction with the fractional vegetation cover derived from MSAVI. SEBAL with one or both modifications showed stronger agreement with the Eddy-Covariance measurements than the non-modified SEBAL. Furthermore, the former showed higher, intermediate, and lower ET values among grasslands, schrublands, and dunelands respectively, while the latter resulted in more homogeneous ET values among land covers and in overestimation of ET over dunelands and underestimation over grasslands. Multiple pairwise land covers comparisons of ET means showed higher potential of the corrected model in discriminating ET. This study suggests that some assumptions in SEBAL tend to inadvertently homogenize ET on these diverse landscapes.

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High Sensitive and Selective Detection of Mercury (II) Ion using Ag Nanoparticles

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Presentation Abstract 13

We describe an absorption-based method to detect Hg(II) ion using polymer-protected silver nanoparticles. The method is very simple yet highly sensitive, with observed detection limit down to 0.2 nM. Most other common ions at 100 times higher concentrations have little interfering effect on the Hg(II) ion detection.

Mercury is a pollutant with well-known toxicological profiles. It is very important for the routine detection of Hg(II) ion in the environmental monitoring of rivers and larger bodies of water and the evaluation of the safety of aquatically derived food supplies. In this report we demonstrate an absorption-based method to detect Hg(II) ion using polymer-protected silver nanoparticles. The presence of Hg(II) ion causes the change of the absorbance spectrum of Ag nanoparticles. The method is very easy to implement, yet highly sensitive (observed detection limit of 0.2 nM) and specific.

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Implementing the Rio Grande into the Hydrology Model SLURP

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Presentation Abstract 14

The Rio Grande rises in the San Juan Mountains of Colorado, flows through the San Luis Valley, and then runs south into New Mexico through Albuquerque and Las Cruces to El Paso, TX. The river continues along the U.S.- Mexico border until it deposits into the Gulf of Mexico. The Rio Grande is the life support for farmers and is used for drinking water in some cities such as El Paso, TX. The Rio Grande is over-appropriated, meaning there are more users for the water than there is water in the river; hence, one of the many reasons the Rio Grande needs to be modeled. SLURP (Semi-distributed Land Use-based Runoff Processes) is a conceptual basin model, which normally is used in semi-distributed form, but is capable of being used as a fully-distributed hydrological model. Using SLURP in a semi-distributed form, the model is able to simulate the behavior of a basin at many points and with many variables while avoiding the data and computation-hungry excesses of the fully-distributed models. The model simulates the hydrological cycle from precipitation to runoff including the effects of reservoirs, dams, regulators, water extractions/diversions and irrigation schemes. The model is being used to examine the effects of proposed changes in water management within the Rio Grande or to see what effects external factors such as climate change or land cover change might have on various water users. SLURP is run on public-domain data sets available on the internet such as climate data, digital elevations data and land cover data. SLURP has been applied to river basins around the world to investigate water resource problems such as the transfer of water from large-scale to small scale farming (South Africa), the effects of dams on fisheries interests (Mekong River) and the consolidation of farms (Germany). This presentation will show the process of implementing the Rio Grande into SLURP, discussing inputs, outputs, and potential forecasted outputs based on particular scenarios.

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Coupled Liquid Water, Water Vapor and Heat Transport in a Sandy Loam Onion Field

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Presentation Abstract 15

Temporal soil moisture variations in unsaturated soils due to temperature gradients are characterized by the water vapor transport in the surface soil layer as liquid water movement could be very small especially when surface soil moisture is low. Numerical model Hydrus-1D was applied to investigate non-isothermal liquid and vapor flow closely coupled with the heat transport in a furrow-irrigated onion field located at Leyendecker Plant Science Research Center, Las Cruces. TDR and temperature sensors were installed to continuously monitor diurnal soil moisture and temperature variations in sandy loam onion beds at 5, 10, 20, and 50 cm depths during the entire growing season. Meteorological data were obtained from PSRC weather station. Hydrus-1D simulated soil moisture and temperature favorably contrasted against measured data at different depths. Simulations indicated that both liquid and vapor fluxes contributed to the water transport near surface. Liquid flux dominated the water movement during an irrigation event, while contribution of vapor flux increased with increasing soil drying. Vapor flux decreased from 2 cm to 7 cm depth, indicating that water vapor flux is much higher in the layer near soil surface. Both diffusive and dispersive transports are responsible for the vapor flux in the near-surface dry zone, while convective liquid flux was the main transport mechanism in the near-surface wet lower zone. In near-surface wet zone, diffusive flux decreased and changed from upward to downward flux.

Key-words: Sandy loam soil, water and vapor fluxes, heat transport, soil moisture, soil temperature, Hydrus-1D model

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WITHDRAWN

Presentation Abstract 16

Manipulating Aquifers in the Subsurface: In Situ Healing and Sealing the Environment

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Presentation Abstract 17

In situ healing and sealing the environment (ISHSE) is a novel concept encompassing innovative technology to solve environmental problems and potentially can be used for manipulating aquifers in the subsurface. It pertains to in situ manipulation of natural processes, affecting the mobility and state of contaminants and the pore structure of geomedia in the subsurface based upon mimicking seal formation as encountered in natural complex systems. The technique involves transport of chemical constituents from two chemically different solid materials followed by precipitating the products of the chemical constituents at the interface of the two materials leading to lower permeability and creating of subsurface barrier. Besides in situ sealing such a barrier is also self-healing in that it will regenerate itself after rupture. Thus any mechanical damage to a sealing layer will cause further migration and precipitation as long as the concentration of reacting constituents suffices. Commonly, immobilization of a large variety of components including toxic ones occurs simultaneous during the process of sealing layer formation by co-precipitation or surface adsorption.

As a case study, two industrial wastes, i.e., acidic jarosity and alkaline fly ash were selected as two chemically different materials. Laboratory radiotracer diffusion tube experiments were conducted to demonstrate the development and characteristics of the in situ sealing/healing layer at the interface of these two wastes and its effect on transport and mobility of chemical constituents from the wastes.

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Four Years Later- How the City of Santa Fe is Using Our Water Management Model

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Presentation Abstract 18

The City of Santa Fe, NM developed a water management and planning decision support model in 2005 to assist the City in managing both the short-term and long-term uses of the City's water supply portfolio. The City's Water Management and Planning Simulation (WaterMAPS) model is built upon the STELLA program and incorporates existing and potential water supply sources allowing City staff to explore management options given the three constraints of physical infrastructure, water rights, and water availability. With the assistance of the WaterMAPS model developer, CDM, the City developed a Long Range Water Supply Plan to the compare the reliability and sustainability of multiple, future water supply options. City staff has used the model to: a) determine that the carry-over storage of approximately 20% within the 4,000 acre-feet (ac-ft) capacity of the municipal reservoirs is the minimum possible, b) understand the impacts of releasing 1000 ac-ft to the Santa Fe River in normal and wet years on the City's overall water supply, c) estimate spring watershed yield from the upper Santa Fe River watershed given March snowpack conditions, and d) determine the optimal amount of water storage the City needs on the Rio Grande/Rio Chama system. The WaterMAPS model is an effective tool that allows the City's water resource managers to understand the ramifications of possible management decisions or policies and the WaterMAPS model provides the City's elected officials the information needed for proposed plans or policy choices.

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Geochemical Processes Controlling Chromium Transport in the Vadose Zone and Regional Aquifer, Los Alamos, New Mexico

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Presentation Abstract 19

The environmental aqueous geochemistry of Cr is of considerable interest to physical scientists and toxicologists in quantifying the fate and transport of this metal in surface and subsurface environments. Chromium(VI) solutions were released from cooling towers to a stream channel within Sandia Canyon at Los Alamos National Laboratory, NM from 1956 to 1971. These solutions have migrated 293 m depth through the vadose zone, containing several saturated zones, to the regional water table. Concentrations of total dissolved Cr, mainly as Cr(VI), in the regional aquifer range between 0.17 to 17.12 uM. The regional aquifer is characterized by calcium-sodium-bicarbonate solution, contains dissolved oxygen (0.09 to 0.22 mM), and has a circumneutral pH (6.8 to 8.3). Geochemical processes controlling the fate and transport of Cr in groundwater at Los Alamos include a combination of adsorption and precipitation reactions within aquifer systems. Vadose zone material containing hydrous ferric oxide, smectite, silica glass, and calcite widely range in their ability to adsorb Cr(VI) under basic pH conditions. Overall, the vadose zone at Los Alamos is relatively oxidizing, however, basalt flows are locally reducing with respect to Fe. Ferrous iron concentrated within the Cerros del Rio basalt has been shown through batch experiments to reduce Cr(VI) to Cr(III) resulting in precipitation of chromium(III) hydroxide. Regional aquifer material, consisting of silicates, oxides, and calcite, vary in the amount of Fe(II) available in reactive minerals to effectively reduce Cr(VI) to Cr(III). The results of our studies (1) directly assess the relationship between mineralogical characterization and transport behavior of Cr using site-specific hydrogeologic material and (2) provide site-specific adsorption and precipitation parameters obtained through the experiments to refine the fate and transport modeling of Cr within the vadose zone and regional aquifer. Natural attenuation of Cr at Los Alamos is a potential groundwater remediation option that needs to be fully assessed within Fe(II)-rich basalt and other aquifer material.

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Hydrologic Modeling of the Mimbres Watershed Using Precipitation Data from Several Different Sources

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Presentation Abstract 20

Two major criteria in choosing climate data for use in hydrologic modeling are the period of record of the dataset and the proximity of the collection platform to the basin under study. Conventional datasets are derived from climate stations; however, in many cases there are no climate stations sufficiently close to the basin to be representative of climate conditions in that basin. In addition, the period of record for the climate station(s) either does not cover the period of the proposed simulation or there are gaps in the data. Therefore, the objective of this study was to investigate alternative climate data sources for use in hydrologic modeling. The modeling tool used in this study was Soil and Water Assessment Tool (SWAT) implemented on the Mimbres River basin in Southwest New Mexico. Because our initial simulations using NEXRAD Stage IV precipitation gave conflicting results for calendar years 2005 and 2006, we decided to investigate the use of precipitation data from other sources. The work presented here compares the performance of NEXRAD Stage IV, SNOTEL, RAWS and COOP gauge precipitation data for modeling runoff. Comparisons between different precipitation datasets were paradoxical as the initial SWAT simulations. This study discusses the SWAT simulation results, intercomparison of different precipitation datasets and the implications on the hydrologic modeling.
Key-words:
SWAT; NEXRAD; precipitation data; rain gauge data; time series analysis; watershed; New Mexico.

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Physical Properties of Clinoptilolite Zeolite and Mixtures with Sand

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Presentation Abstract 21

Clinoptilolite zeolite (CZ) is a natural zeolite with great aptitude of water absorption and high porosity. Several applications can be counted for this mineral and one of them is using it as an amendment for agricultural soil to increase water storage. The main idea of this research was to investigate the impact of CZ addition to sandy soil on moisture storage and some physical properties such as bulk density (BD) and saturated hydraulic conductivity (Ks). Four plots with four replications, instrumented with EC-5 sensors at 0.15 and 0.45 m depths, were selected and in each plot four columns (90 cm x 90 cm x 90 cm) with 100% sand, 80% sand and 20% CZ, 60% sand and 40% CZ, and 100% CZ by volume were constructed, respectively. Sixteen intact core samples were collected from the 0.15 m depth of plots to determine BD, Ks, field capacity, available water content and soil water retention curve. There were no significant differences in effective porosity, available, field capacity and wilting point water contents among CZ, sand and mixtures, because of the large variability among samples. More work is needed to verify these results. The average peak and 24 h moisture content generally increased with the increasing amount of CZ at both depths. The average wetting front velocities at both depths of bare and canopy soils mostly decreased with increasing amount of CZ. These results indicate that water retention capacity of the pure CZ is high and it can be used as an amendment in the field.

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Effect of Electrical Conductivity on the Saturated Hydraulic Conductivity of Some Lining Materials

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Presentation Abstract 22

Groundwater quality is affected by pollutants that move through lining materials due to advection and due to the change in the thickness of diffuse double layer. The objectives of this research were to (1) quantify how saturated hydraulic conductivity (Ks) of the porous media is influenced by different lining materials and bulk density of the porous media, 2) evaluate the effect of desiccation of the soil on the self-sealing/self-healing capacity of the lining materials, and (3) identify a possible lining material for evaporation ponds. Three different chemical compounds, sodium silicate, calcium hydroxide, and magnesium hydroxide, were selected as lining materials. Columns were packed with a layer of lining materials (~10g) between 50 and 10 g of Tularosa soil and subjected to intermittent ponding. The calcium hydroxide and magnesium hydroxide showed self-sealing/self-healing capacity after the formation of cracks in the soil. X-ray diffraction analyses showed precipitation of calcium carbonate and calcium sulfate in the columns where layers of calcium hydroxide and magnesium hydroxide were used as a lining material. The precipitates reduced the water flow through the cracks after each wet-dry cycle. The layers of calcium hydroxide and magnesium hydroxide were better lining materials than sodium silicate and the smallest Ks values obtained by calcium hydroxide, magnesium hydroxide and sodium silicate were 3.46 x 10-7 m/s, 1.35 x 10-6 m/s and 8.98 x 10-6 m/s, respectively. However, Ks of the lining materials was much above the EPA limit of 1 x 10-9 m/s or lower.

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Is There A Role for Rainwater Harvesting in NM Water Resources Management?

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Presentation Abstract 23

Rainwater harvesting is becoming increasingly important for domestic water supply and landscape irrigation in the Southwest. In some States (including Colorado), regulations have recently relaxed to allow intercepting rainwater and some communities (including Tucson and Santa Fe) are mandating that new homes utilize roof water onsite. In some water-short regions of other countries, rainwater harvesting is mandated (for example, many of Caribbean islands). The benefits of rainwater harvesting are many, and extend beyond provision of basic water supply. When properly implemented, rainwater harvesting can reduce flooding, reduce erosion associated with flood events, improve water quality of stormwater runoff (and thus of water bodies that receive stormwater runoff), increase recharge, reduce potential for catastrophic fires by increasing moisture contents of local environments, and provide water storage resource for local fire-fighting.

In New Mexico, there are several factors affecting widespread implementation of rainwater harvesting, including:

- A basic paradigm shift away from traditional stormwater management practices (that is, get rid of stormwater as quickly as possible)
- Local building codes and ordinances, which are often outdated and do not include or allow for rainwater harvesting techniques
- Intrastate and International Water Compacts that allocate water resources in most major river basins of the State

This paper explores the potential for rainwater harvesting to augment water resources in New Mexico and discusses the hydrological, geological, legal and institutional constraints in implementing it.

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Irrigation Scheduling Based on Soil Moisture Statuses in an Irrigated Pecan Orchard

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Presentation Abstract 24

Soil moisture monitoring in a pecan orchard in El Paso, TX indicated that irrigation was applied at a soil moisture point, about 1.9% higher than conventional middle point between the field capacity and wilting point. Further soil moisture simulation using drainage and transpiration equations showed this soil moisture is the minimum tolerable moisture content (Tmin). Tmin is one of five distinctive moisture points or indexes that define four distinctive soil moisture statuses for mature pecan growth. The four statuses are: water logging stress (gas deficit) status, favorable water uptake status, tolerable moisture deficit status, and intolerable moisture deficit status. Among them favorable water uptake and tolerable moisture deficit statuses are two preferable statuses for pecan health growth and good production, while waterlogging (gas deficit) and intolerable moisture deficit statuses are two detrimental statuses for pecan growth. It was also noted that soil moisture statuses are significantly different in three growing stages of irrigated pecan: budbreak; shooting, leafing and flowering; and fruiting. This difference dictates variation of Tmin and gas deficit status in three growing stages, and in turn allows a new design of irrigation scheduling to conserve water. The new irrigation schedule has a varied irrigation-interval and different application rate for each irrigation cycle instead of a biweekly and 45 minutes irrigation plan. Potential for water conservation and production enhancement through this new irrigation plan needs further verification.

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Residence Time Distributions and Dynamically Changing Hydrologic Systems: Exploring Transient Topography-Driven Regional Groundwater Flow

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Presentation Abstract 25

The concept of "groundwater age" is fundamental to answer the question, how old is the water? And, at the same time, it has important implications for the prediction of water migration rates and therefore the assessment of groundwater quality and quantity, the fate and transport of solutes, and risk assessment. A sample of water taken from a groundwater system contains a mixture of molecules, which, in general, resided in the system for different amounts of time; the sample's residence time (or age) is characterized by a distribution rather than a single value. This distribution is called the residence time distribution (RTD) and is determined by the system's flow and transport characteristics, the location or type of sample, and how water entered the system. Traditionally, observed and modeled RTDs are evaluated under the assumption of steady-state flow conditions, but spatial and temporal variability in weather and climate forcings induce a dynamic response in hydrologic systems that is inherited by the flow paths and RTDs. Groundwater systems are driven by forcings varying at several time scales: daily, seasonal, interannual, decadal and much longer. In this work, we explore the effect that flow dynamics, induced by climatic variability, have on RTD for a regional groundwater system. A Tothian-like domain is used to illustrate this issue, showing the importance of input and observation times for RTDs under dynamic conditions.

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Renewable and Sustainable Approaches for Desalination

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Presentation Abstract 26

Freshwater and energy are essential commodities for well being of mankind. Due to increasing population growth on one hand, and rapid industrialization on the other, today's world is facing unprecedented challenge of meeting the current needs for these two commodities as well as ensuring the needs of future generations. One approach to this global crisis of water and energy supply is to utilize renewable energy sources to produce freshwater from impaired water sources by desalination. Sustainable practices and innovative desalination technologies for water reuse and energy recovery (staging, waste heat utilization, hybridization) have the potential to reduce the stress on the existing water and energy sources with minimal effects on the environment. This paper discusses existing and emerging desalination technologies and possible combinations of renewable energy sources to drive them. It is suggested that a holistic approach of coupling renewable energy sources with technologies for recovery, reuse, and recycle of both energy and water can be a sustainable and environment friendly approach to meet world's energy and water needs.

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Can Water Utilities Flush Distribution Systems Annually and Still Lead by Example in Water Conservation, Especially During Times of Drought and Population Growth - and Shouldn't They?"

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Presentation Abstract 27

Every year, water utilities open fire hydrants and flush vast amounts of water to waste down storm drains – and typically into rivers - to ensure water quality, safety, and meet regulatory standards.

At the same time, as the climate warms and supplies dwindle, customers are told to conserve every drop, with mandatory rationing becoming commonplace. When customers witness fire hydrants running full blast during annual flushing programs - sometimes for an hour or more - their astonishment is exceeded only by their anger.

Flushing programs are commonly performed eight hours a day for 4 months every year - or more.

The question that begs answering is "Can water utilities flush distribution systems annually and still lead by example in water conservation, especially during times of drought and population growth - and shouldn't they?"

During droughts or when supplies are limited, flushing programs may be suspended - at the risk of compromising water quality and safety.

An overview of currently used flushing methods – conventional and uni-directional – will be given, including video of this wasteful practice. An in-depth presentation of the new NO-DES method will be made and the three will be compared relative to:

- Effects on water conservation – amount of water needed, impact on supplies,
- Effectiveness in maintaining or improving water quality and controlling bio-film.
- National Pollution Discharge Elimination System issues they raise or eliminate
- Their ability to enable the utility to "Lead by Example in Water Conservation" by demonstrating they are practicing what they preach.

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Domestic Uranium Contaminated Groundwater Remediation – Sorption and Immobilization Technology via New Mexico Structurally Layered Phyllosilicates

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Presentation Abstract 28

Uranium contaminated water is problematic for households and communities in the Four Corners, and the situation will worsen in the near future with projected, re-established mining. Our objective is uranium abatement in water to supply potable water for households in the affected rural areas. Structured layered phyllosilicates will sorb thus removing uranium. The manageable end-product is easy to handle and dispose. The purified water can simply be decanted or drained and the contaminated sorbent removed easily and safely. The overall process is deliberately simple, economic, and a user-friendly small-scale technology. Preliminary tests show the efficacy of this technology. Inductively coupled plasma mass spectroscopy has illustrated uranium uptake to ppb levels by means of sorption isotherms. At constant ambient conditions, the uranium concentration decreased from 500 ppb to 132.40 ppb in the first fifteen minutes. The reduction to 26.13 ppb, a concentration below EPA's safe drinking water limit of 30 ppb, occurred within the next hour and a half. The final uranium concentration was 1.5 ppb after 8 hours of exposure to the layered phyllosilicates. The sorption model was verified with an orthogonal fluorimetric technique. The importance of this technique is that it is non-destructive and most suitable for kinetic modeling (Dolezel et al., 1993). Excitation and emission wavelengths were optimized for analyses in ppm and possibly ppb ranges. Precise uranium calibration curves permit sorption isotherms, kinetic studies and modeling. This project focuses on a New Mexico solution for a New Mexico problem.

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Santa Fe Paired Basins Investigation

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Presentation Abstract 29

The New Mexico Interstate Stream Commission, with support from the City of Santa Fe, the Santa Fe National Forest, and Sandia National Laboratory is conducting research to understand the potential changes in water yield resulting from forest thinning activities. Two sub-basins of about 400 acres in the Santa Fe Municipal Watershed (one thinned and one unthinned) have been instrumented to enable estimation of the following water budget components: soil moisture storage, snow pack, precipitation, surface run-off, groundwater recharge, and evapotranspiration. The study will investigate hydrologic changes that occur over time as vegetation is re-established in the treated sub-basin. While long-term data are necessary to make conclusive interpretations, preliminary data suggest differences in run-off dynamics.

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21st Century Drought Scenarios for the Western U.S.

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Presentation Abstract 30

As global anthropogenic climate change evolves into a theory with a greater foundation of empirical support and, hence, gains in credibility, there are many questions for scientific research to address. Specifically, the question of how future temperature changes will influence the availability of water is integral to water resource management, and this question can be explored through the computation and analysis of drought scenarios. This study undertakes the generation of such scenarios through use of a program designed to compute the monthly Palmer Drought Severity Index (PDSI) for individual climate divisions. The PDSI is designed to describe the surface water balance and show changes in soil moisture, using as inputs temperature and precipitation (observations of which are more readily available than soil moisture data). The future PDSI values presented here incorporate temperature and precipitation trends for the twenty-first century derived from global model simulations used in the 2007 IPCC AR4 report, as described in a companion presentation by D. Gutzler, and are illustrated using graphical display of associated statistics. For this study, this method has been applied to climate divisions of the western U.S., with special focus on scenarios applicable to New Mexico, to gain improved insight into future changes in the severity, duration, and frequency of drought. Overall, results suggest increasing severity, duration, and frequency of drought during the twenty-first century, especially in the latter half as higher evaporation rates associated with positive temperature trends prevent recovery from droughts caused by precipitation deficits.

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What Streambank-Storage Models Tell Us About Floods in Karst Cave Conduits

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Presentation Abstract 31

Over forty years ago (1963) Cooper and Rorabaugh (CR) of the USGS developed a simple but important one-dimensional, linear model describing streambank-storage of a passing flood wave in stream or channel. Given the flood wave history, the model explained water level changes in the aquifer bounding the channel, estimated flux rates between channel and aquifer, and modeled the time history of the volume of bank storage. From the latter you can determine the portion of the aquifer impacted by the unique chemical fingerprint of channel water. The model did not account for feedbacks, such as attenuation of the flood wave by bank storage.

Since karst conduits are analogous to surface streams, we borrow the concepts in the CR model, to study matrix-storage of a passing flood wave in a phreatic (fully saturated) cave conduit. For a conduit far below the water table, flood induced storage can be described with the radial flow analog of CR's semi-infinite model. For a shallow conduit, superposition is employed to model the geometric effect of the water table, although it neglects specific yield at the water table. The model is then used to study the effect of increased matrix-conduit interaction due to flood wave storage in the matrix, as well as the impact on the matrix-aquifer by the unique chemistry of the conduit water.

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An Aqueous Geochemical and Hydrologic Study of the Springs and Wells of the Sevilleta National Wildlife Refuge: Evaluating Salinity Contributions

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Presentation Abstract 32

This study reports hydrochemical data collected from springs and groundwaters within the Sevilleta NWR. The Rio Grande is an important water source, but the smaller rift springs are also a vital resource for livestock and wildlife. We test the hypothesis that springs located on rift-bounding faults exhibit a mixing of meteoric recharge with small volume "endogenic" fluids that ascend along faults. The deeply sourced fluids may contain contributions from the lithospheric/asthenospheric mantle and/or upwelling sedimentary basin brines.

Geochemical data show variability in Sevilleta geochemistry, with differing water chemistries corresponding to specific areas and water sources. This small area demonstrates most of the variability in the Albuquerque basin, making it an important testbed for understanding geochemical variations in the rift. Longitudinal Rio Grande sampling confirms a significant salinity input to the modern river focused near the San Acacia springs and brine pools. A previous mechanism for salinization of the river involves upwelling of brines at interbasin constrictions, but our data suggest a contribution by high-chloride waters upwelling along deeply penetrating rift-bounding/intrarift faults. Field parameters and hydrochemistry suggest a “fast path” for endogenic fluids. Mixing with possible sedimentary basin brines is possible, and upwards movement along faults provides a mechanism for ascent of otherwise stagnant deep basin brines.

Recognition of the salinity source represented by endogenic fluids allows for an improved understanding of river water quality degradation. Springs help establish and sustain unique ecosystems such that better understanding of their chemistry is essential for mitigating changes due to increasing demands on groundwater.

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Quantifying Groundwater/Surface Water Interactions along the Rio Grande to Assess the Sustainability of Desired Flows for River Management and Restoration

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Presentation Abstract 33

Sustaining desired river flows under a variety of inflow, water use and climatic conditions is critical to meeting downstream delivery obligations and to maintaining adequate riverine habitat on the Rio Grande in New Mexico. For the Rio Grande between Cochiti and Elephant Butte reservoirs, a series of high-resolution groundwater models have been developed for the near-river zone to provide insight on surface water/groundwater interactions that variously impact the degree of river gains and losses, and the ability to sustain desired flows in specific river sub-reaches given changes in regional groundwater conditions, flood magnitude and duration, and following drought. The model domains include the river channel, overbank area and parts of the adjacent floodplain, and the underlying shallow alluvium. Processes modeled include seepage from the river, interception of shallow groundwater by drains or the river, recharge to shallow groundwater from flooded overbank areas and water depletions due to open water evaporation and riparian evapotranspiration. Transient river boundary conditions are modeled using flow-dependent river width and depth, obtained from companion surface water models. Information used in model calibration includes seepage run results and groundwater elevation data under variable flow conditions. The models are applied to potential water management and restoration scenarios to assess the sustainability of river flows under variable external conditions. Case studies are provided.

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PRELIMINARY VALIDATION OF RADARSAT-2 FOR ESTIMATING SURFACE SOIL MOISTURE

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Presentation Abstract 34

Previous studies have shown that surface soil moisture measurements by Synthetic Aperture Radar (SAR) can be quite accurate under conditions of low surface roughness and bare or sparse vegetation. The present study focuses on the validation of RADARSAT-2 for measuring surface soil moisture under different types of vegetation density and surface roughness. RADARSAT-2 was launched in December 2007 and is the first SAR sensor to offer an operational quad-polarization mode. This mode allows to generate soil moisture (and cm-scale surface roughness) maps from single data sets. Therefore, it is expected that RADARSAT-2 surface soil moisture maps have an improved quality compared with those obtained by other older radar satellites. We will present RADARSAT-2 soil moisture maps, field soil moisture measurements, and soil moisture maps derived from optical imagery.

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A Hybrid Treatment Process for High TDS Oil-field Produced Water

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Presentation Abstract 35

South Eastern New Mexico (SENM) produces in the range of 400 million barrels of produced water per year, with total dissolve solids (TDS) in the range of ~ 200,000 ppm. Most often, disposal is done by transporting the water long distance to disposal-ponds, costing around ~$1.2 billion /year using an estimated 0.3 million barrels of transportation fuel. The objective of this current project is to design, develop and demonstrate the best possible technology economically achievable to desalinate produced water and make the same suitable for a number of applications.

Reverse Osmosis (RO) is quite effective for desalination of water with TDS < 30,000 ppm i.e., sea water. As the amount of TDS increases, there is a disproportionate increase in the requirement of pressure for the RO process, making the process very expensive. In this context a hybrid process based on forward osmosis (FO) is under development using draw solutions that can induce high osmotic pressure at no applied external pressure. Current presentation compiles issues and opportunities associated with this hybrid technique. A number of pretreatments, including ones suggested by Late Prof. Robert Bowman, were investigated to reduce fouling and scaling potential of the membranes. Feasibility of using this hybrid process to economically treat produced water will be analyzed and discussed.

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Upper Rio Grande Water Operations Model (URGWOM)

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Presentation Abstract 36

The Upper Rio Grande Water Operations Model (URGWOM), a suite of modeling tools to assist water managers in unified operations of the Upper Rio Grande, is a joint effort by six federal agencies and several cities, water districts, research institutes and interested NGOs. These organizations collaborated to develop a numerical computer model capable of simulating water storage and delivery operations in the Rio Grande from its headwaters in Colorado to below Caballo Dam in New Mexico. The model(s) are used in flood control operations, water accounting, and evaluating water operations alternatives. The URGWOM was developed using RiverWare™, an object oriented general river and reservoir modeling tool developed at the Center for Advanced Decision Support for Water and Environmental Systems (CADSWES) at the University of Colorado at Boulder. RiverWare™ provides modeling of water ownership and ability to specify operational rules that include information about water accounting as well the physical system. The structure of the physical system as represented in URGWOM was recently modified to a more physically based representation of groundwater-surface water interaction along the Middle Rio Grande. With the representation of the physical system in URGWOM and methods for key physical processes in the basin, changes in operations or other proposed actions can be analyzed with URGWOM to evaluate the impact on the water supply, river flows, and water deliveries. URGWOM provides a means to efficiently analyze innovative solutions to meeting the increasing water demands throughout the Rio Grande basin in New Mexico.

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The NMOSE Lower Rio Grande Groundwater Model: A New, Collaboratively-Developed Model to Support Water Resources Management in a Transboundary Setting

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Presentation Abstract 37

The New Mexico State Engineer Office recently released a new groundwater model (LRG_2007) to support water resources management in the Lower Rio Grande Basin. The model domain includes the Rincon and Mesilla Basins, and extends beyond New Mexico into Texas and Mexico. The modeled area is traversed by the Rio Grande, which is included in the model along with a detailed representation of the irrigation canal and drain network. This model was developed over a multi-year period through a collaborative process involving a Calibration Committee, comprised of technical representatives of several stakeholders. The Calibration Committee compiled and analyzed available data, including flow and groundwater level data spanning the last century, aquifer test data and recently developed spatial data, such as irrigated areas identified by the Lower Rio Grande Hydrographic Survey. The recently developed hydrogeologic framework model of Hawley and Kennedy (2004), and information provided by new deep wells drilled by the NMISC were also used in developing the model. Because so much new information was available since the development of predecessor models, the Committee chose the approach of building a new model from available data; rather than the approach of modifying an existing model.

The 5-layer Lower Rio Grande Groundwater Model consists of 388 columns and 164 rows of quarter-mile square cells. The Rio Grande, canals and drains are incorporated with over 400 stream segments in the SFR package and with historic flow and diversion data. Irrigation well pumping and irrigation recharge are calculated in an external spreadsheet model using detailed historic surface water supply records and calculated crop water demands, which is then converted into model input files. Riparian evapotranspiration is represented with the RIP-ET Package, using spatial delineations of riparian vegetation, and vegetation-specific ET-water depth relationships. Historic model simulation extends from 1940 to 2004, a period including a wide range of water supply conditions, from extreme drought to very wet periods. Calibration targets include groundwater level data and groundwater discharges to irrigation drains and to the mainstem of the Rio Grande. Model calibration efforts included (1) both automated and manual adjustments of parameter values, (2) revaluation of various input values such as historic trends in farm efficiency, and (3) refinements of representation such as the duration of canal diversions during drought periods. The model is being used as a predictive tool to anticipate impacts from a variety of potential changes expected in the future, and as a tool for water rights administration. The model is well-suited for evaluating the impacts of groundwater pumping on surface water in both the river and drains; for evaluating alternate well pumping scenarios including changes in pumping patterns within the transboundary region; and for assessing hydrologic changes associated with alternate water supply conditions, whether operational or climate-related.

Current work with the model (by the authors and by other researchers) includes 1) future projection runs to simulate changes in water management and crop demands, 2) conjunctive runs with a RiverWare model that is being developed by the NMISC to simulate changes in Rio Grande Project Operations, 3) modification of the model to replace the external irrigation-related calculations with the newly-developed MODFLOW Farm Package, 4) improvement of the model simulation of the Mexican part of the Mesilla Basin, and 5) linkage with a groundwater model of the Southern Jornada del Muerto.

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