Curb the Urge to Purge: Is Now the Time to Switch to No-Purge Ground Water Sampling

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Presentation Abstract 1

In the United States and abroad, the collection of environmental ground water samples using no-purge, discrete interval, sampling methods is arguably the fastest growing segment of the groundwater-monitoring field. Each year tens of thousands of samples are collected using no-purge sampling devices with continued growth in use occurring year after year.

Why? No-purge sampling methods provide formation quality groundwater samples using a much simplified and repeatable groundwater sampling method. In today's economic environment, the simplicity and low equipment cost enable users of no-purge sampling methods to dramatically reduce field time and sample acquisition expense while maintaining data quality. A 50 to 80% reduction in field time and cost are common. In addition, no-purge sampling is a less energy intensive method of collecting groundwater samples, producing a much smaller carbon footprint than conventional sampling methods.

This presentation will briefly describe the basic principals of no-purge sampling, how and why it works, and examine the difference between it and traditional well purging methods. Commonly used no-purge sampling devices will be discussed as well as the advantages and limitations associated with no-purge sample collection.

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Using an ADCP to Determine Canal Seepage Loss in an Irrigation District

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Presentation Abstract 2

Seepage from earthen irrigation canals represents substantial water loss in irrigation districts. Historically, the determination of canal seepage was accomplished using the inflow-outflow method with propeller and electromagnetic type flow meters. This method was difficult, time consuming, and limited by measurement device accuracy. In recent years, advances in technology have lead to the widespread use of Acoustic Doppler Current Profilers (ADCP) for discharge measurements in streams and rivers. Even though ADCP use has become widespread for stream discharges, studies to determine canal seepage using this new technology are limited. Using an ADCP, extensive field measurements were conducted in the Middle Rio Grande Conservancy District. This paper describes the ADCP measurement protocol used to measure irrigation canal seepage and presents predictive equations for determining canal seepage based on flow rate and canal geometry.

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Living Off-Grid in an Arid Environment Without a Well – Can Residential and Commercial/Industrial Water Harvesting Help Solve Water Supply Problems?

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Presentation Abstract 3

Our family of three lives comfortably off-grid without a well in an arid region (~9 in/yr, average). This year we expect to achieve water sustainability with harvested or grey water supporting all of our needs (including a garden and trees), except drinking water (about 7 gallons/week). We discuss our implementation and the implication that for an investment of a few thousand dollars, many single family homes could supply a large portion of their own water needs, significantly reducing municipal water demand. Generally, harvested water is very low in minerals and pollutants, but may need treatment for microbes in order to be potable. This may be addressed via filters, UV light irradiation or through chemical treatment (bleach). Looking further into the possibility of commercial water harvesting from malls, big box stores and factories, we ask whether water harvesting could supply a significant portion of potable water by looking at two cities with water supply problems. We look at the implications of separate municipal water lines for potable and clean non-potable uses. Implications on changes to future building codes are explored.

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Harnessing the Power of New Mexico's Dairies

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Presentation Abstract 4

New Mexico dairies are facing a problem of "critical mass." While the dairy products benefit the state economically in many ways including taxes and jobs, the resulting waste is a dilemma of regional scope. Groundwater contaminant plumes of significantly elevated nitrate, chloride, and total dissolved solids exist at nearly each significant dairy in New Mexico prompting specific regulatory action by the New Mexico Environment Department. R-Qubed Energy, working with a local consortium of dairy producers and leveraging on existing European expertise provided by its technological partner Entec Biogas USA, is developing a full-scale anaerobic digester to accept liquid and solid wastes from dairies in Dona Ana County, New Mexico. The resulting energy production at full development of this facility is anticipated to reach nearly 1 billion cubic feet of renewable methane per year while addressing the disposal and contaminant issues associated with 60,000 dairy cattle. Almost 1 million gallons per day of wastewater and 2,500 tons per day of solids will be fed through the combination of digesters, composting operations and the dedicated wastewater treatment facility, significantly reducing one of the largest sources of groundwater contamination while at the same time reducing the uncontrolled generation of greenhouse gases produced during the natural decomposition of the waste.

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Evolution of Groundwater Chemistry During Surface Runoff and Infiltration Processes

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Presentation Abstract 5

The present study attempts to investigate how water chemistry evolves during the infiltration and surface runoff processes, and to define potential flow paths for southern Nevada's groundwater, through initiation of a surface runoff sampling network. The design and emplacement of sixty surface runoff samplers at thirty separate locations is explained in this study and a look at initial data is provided. The sampling process continued for approximately one year, and included surface runoff, precipitation, and sediment samples. In total, 506 samples were collected during the sampling periods, distributed as 275 surface runoff samples, 45 precipitation samples, and 182 sediment samples. The initial reading of the sampling results indicates that there is a high similarity between groundwater and surface-runoff chemistry with the groundwater being a more concentrated version of the surface water runoff. This suggests that surface-runoff is a main source of groundwater recharge especially in the ephemeral arroyos. Further sample collection, statistical analysis, and infiltration modeling are required to answer the question: how/when can surface runoff reach the groundwater in the arid regions?

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Performance of a Green Roof Model in an Arid Climate

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Presentation Abstract 6

Green Roofs, also known as living roofs or eco-roofs, have become part of American architectural and engineering design. Although soil roofs have been in use for as long as adobe bricks, modern green roofs have a larger-scale function. Modern green roofs are used to solve or mitigate a number of architectural and engineering, stormwater management, and ecological problems, especially in urban settings with large impervious areas. The effectiveness of green roofs in solving these problems has been studied primarily in wet to moderately wet climates; relatively little research has been performed in arid or semi-arid climates. This paper describes a preliminary evaluation of the applicability of green-roof technology in arid and semi-arid environments, as well as the analysis of data collected from a physical model of a green roof. The physical model, which was a scale model of the green roof on the new Pearl Hall at the University of New Mexico, was monitored for one year under climatic conditions typical of Albuquerque, New Mexico, an urban setting in an arid region. The data collected included: volumetric soil moisture content in the growth medium over extended dry periods interspersed with monsoonal precipitation events; a bulk analysis of the substrate, and a preliminary water balance for the growth medium.

The results of this study suggest that eco-roofs in arid and semi-arid climates, with or without plantings, can aid in urban stormwater management. Precipitation events in the southwestern United States can be of mild or low intensity, except during the monsoon season which is characterized by intense precipitation events that deliver large volumes of water over a short time-span. During the monsoon season monitored in this study, two localized rains of over 25 millimeters were delivered in less than twenty minutes. As a storm surge in an urban area this volume of water demands an extensive stormwater management system to carry it away. The results of this study suggest that with a green roof in place, ninety-six percent of an average monsoon-season precipitation falling on that roof will not be added to a stormwater runoff pulse. The two storms over 25 millimeters that were recorded by the study rain gage, which were the only storms to produce a water yield through the physical model's drain, retained fifty-four and fifty-eight percent of the precipitation and delayed the surge by fifteen and thirty-five minutes respectively; a total of 96% of all precipitation was retained by the Pearl Hall scale model. The retention and delay of runoff is a principal goal of the current stormwater best management practices being encouraged by the U.S. Environmental Protection Agency.

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Selective Recovery of Desalination Concentrate Salts Using Interstage Ion Exchange

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Presentation Abstract 7

The presentation will present results from a research project focused on the selective recovery and beneficial reuse of salts and minerals from RO concentrate. Benefits of this process include increased potable water recovery, the generation of salts or minerals that might have commercial value, and reduced concentrate volume. This research has investigated the use of ion exchange (IX) as an intermediate step in an RO system to remove scale forming ions and to allow for creation of salts for beneficial reuse. After treatment in a 1st-stage RO system, IX columns remove cations and anions from the concentrate, replacing them with sodium and chloride to reduce scaling potential. Ion exchange theory suggests that the ions form distinct bands within the IX column. Research is currently in progress to verify the ion distribution and to investigate ways to capitalize upon this phenomenon to create selected salts for beneficial reuse. A 2nd-stage RO system increases the overall product water recovery and generates a concentrated sodium chloride solution that can be used to regenerate the IX columns. Experiments are currently in progress to characterize the exchange characteristics of IX resins under high ionic strength conditions, to optimize the exchange process and regeneration processes, and to optimize the mixing/precipitation process to control the recovery of specific salts. The research is funded by the WateReuse Foundation. A provisional patent application has been filed for the process.

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Reference Evapotranspiration Toolbox

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Presentation Abstract 8

This paper introduces the Reference Evapotranspiration toolbox (RETT) running under MATLAB (The Mathworks, Inc) for computing the Reference Evapotranspiration (ET) from the available weather data. The RETT includes tools for downloading the weather data from the National Oceanic and Atmospheric Administration (NOAA) website, extracting the desired weather data fields from the GRIB and GRIB2 data files, processing the hourly and daily weather data, interpolating missing or bad data, computing the daily reference ET values and visualizing the results using Google Earth. Toolbox functions can be used in many platforms including PC and Unix based systems. The toolbox is freely available at http://remotesensing.nmsu.edu/ for non-commercial use and open source development.

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Multi-National Collaborative Modeling of Water Dependent Resources in the Tigris-Euphrates River Basin

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Presentation Abstract 9

A team of scientists and engineers from the Iraq Ministry of Water Resources, the Iraq Transition Assistance Office of the U.S. Department of State, UNESCO, and Sandia National Laboratories collaborated to build a systems model of Iraqi water resources and related systems, including transboundary water systems, surface water and reservoirs, agriculture, salinity, municipal and industrial uses, and issues related to the restoration and maintenance of the southern Mesopotamian Marshes. The model is intended to assist scientists and planners in the government of Iraq in development of its long-term Strategy for Water and Land Resources. The model is a numerical simulation built in a system dynamics environment, is bounded spatially by the watershed of the Tigris-Euphrates river system, and operates on a monthly timestep from 1930–2047. Model results for the 78-year period from 1930–2007 are calibrated to historic data. The 40-year "scenario period" from 2008–2047 allows users to simulate various and competing future scenarios for water management, and management of related systems, in Iraq. The model shows the potential impact of development of reservoirs and agriculture in upstream countries Turkey, Syria and Iran, and the impact of changes in Iraq to reservoir operations, agricultural practices, municipal and industrial approaches, and marsh restoration efforts. The modeling project is part of Iraq's long-term planning effort known as Strategy for Water and Land Resources in Iraq. Due to the political sensitivity of water issues in the Tigris and Euphrates River system, data used to drive this model, and specific model results are proprietary to the country of Iraq. As a result, this paper will not include quantitative results, but rather a qualitative description of the model building process, qualitative model results, and lessons learned from this multi-national and multi-cultural collaborative model building effort.

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Ultimeter, Measuring Flow the Easy Way

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Presentation Abstract 10

Water measurement is an essential part of water right adjudication. The New Mexico Office of State Engineer requires measurement of flow in all groundwater points of use. The most common flow measuring device is propeller meters which provide instantaneous as well as cumulative flow measurement. The propeller meters are installed in the delivery pipe. The problems with this type of propeller meters are high initial cost, obstruction and reduction of flow, and increased pumping cost. A typical flow meter installed in an 8 inch delivery pipe costs between $2000-$3000, reduces the flow by about 30-40 percent and increases the energy cost by adding 10 to 15 psi of additional head loss to the system. The Ultimeter is a patented device developed at New Mexico State University which uses a small parallel pipe with a low cost small flow meter ($50-$100) to accomplish the same objective without reducing the flow or increasing the pumping cost.

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Optimization of Electrodialysis Reversal Desalination Process and Influence of Operating Parameters on Separation Percentage and Current Efficiency

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Presentation Abstract 11

In recent times, an increase in water crises and a gradual reduction of groundwater levels have given rise to the development of emerging water desalination techniques. The electrodialysis reversal (EDR) process is the most prominent water treatment process used today. EDR is based on the principles governing the behavior of ionic solutions when subjected to direct current potential. In EDR, the performance can be evaluated by two important factors: separation percentage (SP) defined as the amount of salts removed from the feed water to obtain a potable product, and current efficiency (CE) defined as the measure of how effectively ions are transported across the ion exchange membrane for a particular applied current.

This study demonstrates the influence of operating parameters like temperature, flow-rate, and voltage on SP and CE. The experimental design addresses two and three level factor design with experiments conducted at a flow-rate of 7, 9, 11 gpm; temperature of (15 and 30°C) and voltage of 15, 25, and 35 V. Graphs are plotted for both divalent and monovalent ions from which we can study the effect of parameters on SP and CE. Statistical analysis such as ANOVA (analysis of variance) is used to determine which parameters have a significant influence on the yield. The outcome of this study demonstrates the optimized operating parameters to achieve lower cost and higher performance.

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Modeling of Electrodialysis Reversal (EDR) Process Associated with the Energy Consumption

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Presentation Abstract 12

Electrodialysis reversal (EDR) is a process that is used for the desalination of brackish water. The EDR equipment consists of a stack of ion exchange membranes between two electrodes. The electric potential that is supplied to the electrodes acts as a driving force for the ions to separate and migrate through the membranes. Therefore, there are two streams called the dilute and concentrate. In EDR, reversal refers to the timely reversal of the polarities of the electrodes as well as the switching of the hydraulic streams. In the case of EDR, during the reversal operation, the acid produced in the previous cycle helps to clean the scale formed, thus, making EDR a self-cleaning process. By using a mathematical model formulated after the Sonin and Probstein model, we can predict the energy consumption by the EDR for desalination of brackish water. The major assumptions are: laminar flow conditions, smooth channel, and parabolic distribution of concentration in the transverse cross-section of the channel. All models developed previously were compared to the data available from 1-1 electrolytes (compounds consisting of equal numbers of +1 and -1 ions). This model is verified by the experimental data obtained using brackish groundwater.

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Trends in Headwater Flows in response to Global Warming in the U.S. Southwest

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Presentation Abstract 13

Water resources managers and planners in arid regions such as the southwestern United States are becoming increasing concerned about water availability and its variability due to climate change. The authors made a trend analysis of the gage flows in response to global warming since 1950s at five headwaters in the southwestern United States. A two-line model with a slope reversed from positive to negative is used in this analysis. It was found that the annual headwater flow increased in response to global warming at a lower anomaly between 0 and +0.14°C during 1975 to 1983 but has been decreasing in response to global warming at a higher anomaly greater than +0.14°C since 1983. The global warming temperature anomaly threshold is +0.14°C for the headwater flow to switch from a positive response to a negative response to global warming, which most likely occurred around 1983. From these results the authors concluded that hydrologic wet with global warming occurred during 1970s through 1998/1999 in the head watershed area. Hydrologic drought with global warming has happened since 1999/2000. A trend dry or an extreme drought would occur in 2040s in this area when global warming reaches a higher level of about 1.1°C in anomaly based on IPCC projection. This portends a coming crisis in water supply in the southwestern U.S.

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Utilizing GPS and GIS to Model and Analyze Water Distribution Systems in San Juan County, New Mexico

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Presentation Abstract 14

Today, many water distribution systems are using some form of remote meter reading technology. Meanwhile, the meters themselves are being lost. Leaks are difficult to locate and fix, and water is being wasted. In a world with increasing demands for water, it is important that we attempt to conserve as much water as possible.

In order to help maximize efficiency in San Juan County, New Mexico, the San Juan Water Commission is employing GPS and GIS to locate and catalog the features of water distribution systems as well as their attributes. The features being cataloged include main and lateral lines, storage and treatment facilities, fittings, valves, hydrants, pumps, meters, and any other features present in the system. Systems can then be mapped and modeled for analysis, which helps with infrastructure, asset management, and development trends. The model can also be used to track inventory, improve customer service, prepare maintenance workers for repairs, and in turn help maximize efficiency.

The goal of this project is to model the distribution systems of all of the member-entities of the San Juan Water Commission. Paired with existing data on water usage in the county, an invaluable tool for the future will be created. Once our goal is reached, we will gain a better understanding of water usage throughout the county. In doing so, cities and rural water associations in San Juan County will be given a tool with which they will be able to better serve their customers while planning for future needs.

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Evaluating Sensitivity Analysis and Autocalibration of a Semi-Distributed Hydrologic Model for a Semi-Arid Watershed

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Presentation Abstract 15

Distributed hydrologic models can simulate water balance components but need a high amount of data inputs and a large number of parameters that are not easily optimized. Sensitivity analysis is helpful for model calibration and simulation using less parameters. In the present study we applied the Soil and Water Assessment Tool (SWAT) to the Embudo Creek watershed located in Northern New Mexico for the period from 2004-2008 to evaluate model performance from three different parameter datasets derived from the model's 27 flow parameters. In the first case, 10 parameters that were determined to be most sensitive based on the sensitivity index greater than or equal to 0.2 as determined by the auto-sensitivity tool in SWAT; in the second case, visual judgment was used to determine the most sensitive parameters (in this case, 11 parameters). It should be noted that 8 of the 27 parameters were found to be non-sensitive. The manual sensitivity analysis was accomplished by changing each parameter, one at a time, by using first the minimum and then the maximum value. The third parameter dataset included all 27 flow parameters. The impact of these three datasets on model output was determined by using the auto-calibration tool in SWAT only for those parameters in each dataset. The highest produced Nash-Sutcliffe Efficiency (NSE), 0.687, was obtained from the parameter dataset based on the visual judgment. These results suggest that the auto-sensitivity tool is not necessarily the best source for determining those parameters to be used for model calibration.

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Improving the Electrodialysis Reversal Desalination Method to Obtain a Higher Water Recovery Rate at Lower Cost

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Presentation Abstract 16

Electrodialysis reversal (EDR) desalination is known as an excellent method to clean membranes. Membranes are cleaned by reversing the polarity between positive and negative and by switching the hydraulic flow between concentrate and dilute streams in every fixed polar reversal interval. Due to its advantages, researchers are trying to find ways to improve EDR through spacer improvement, membrane ability to withstand calcium sulfate, relaxing the fouling layer in a membrane, and perm-selectivity of the membrane. The spacer model was improved from Mark III to Mark IV to promote turbulence and to increase the utilization area from 64 to 74%; to lower power consumption from 0.14 to 0.10 kWh/m3; and to increase the conductivity reduction from 27 to 36%. The aliphatic anion selective membrane (AR 204 SXZL) ability to withstand sulfate fouling was improved to a saturation level of 440% CaSO4 to gain a calculated water-recovery rate (Rc) of 93.5% in a high level (42%) of SO42- in feedwater without pretreatment but with acid and anti-scalant additions. However, water leaked significantly from the membrane because the metered water recovery rate (Rm) of 86.0% was different from the calculated Rc (93.5%). Although the membrane has the ability to withstand the saturation level of CaSO4 to 440%, the set objective was not achieved due to the hydraulic leak. The research in reverse osmosis stated acid and antiscalant addition decreases the permeability rate. To gain the higher Rc (equal Rm) with a lower desalination cost, research in hydraulic leaks, acids, and antiscalant additions must be revised in EDR.

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Limiting Current Density as a Function of Electrolyte Temperature, Concentration and Flow-Rate/Velocity in Desalination of Brackish Water by Electrodialysis Reversal

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Presentation Abstract 17

Among various desalination techniques available on the market, the focus here is on electrodialysis reversal (EDR). In this process/technology, voltage is applied to remove ions from brackish water in a continuous manner by employing electricity as the energy source for desalination. Specifically in EDR, the polarity of electrodes is reversed at equal intervals of time to increase its performance. Even though high ranges of voltages are suitable for higher removal of salt, operational costs and other factors demand optimization of power. One such factor is limiting current density (LCD), which is the maximum current that can be applied in order to attain maximum separation. Previous studies carried out in this regard have been conducted under conditions such as: 1) single salt solutions prepared in the laboratory, utilizing pure deionized water, 2) studies with ED, and 3) seawater, while using EDR as the desalinating technique. This presentation aims at maximizing efficiency and optimizing the current and voltage supply to the EDR by obtaining the limiting current densities at a pilot scale EDR system installed at the Brackish Groundwater National Desalination Research Facility (BGNDRF) in Alamogordo, NM. The pilot setup is equipped with two membrane stacks and a multi-stage filter as pretreatment. LCD is dependent on various parameters such as temperature, velocity, flow-rate, concentration of the feedwater, and voltage applied to the stack. LCD is obtained from parmeters highlighted earlier and I/V curves. Relations between temperature, velocity, flow-rate, and concentration of feedwater with the LCD are determined experimentally to validate existing theoretical equations.

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Presentation Abstract 18
Withdrawn

Marrying Disparate Data Sources in Developing a Groundwater Flow and Transport Model of the Alamitos Gap Seawater Intrusion Barrier, Los Angeles and Orange Counties, CA

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Presentation Abstract 19

Developing a hydrogeologic framework for a complex system of aquifers remains a challenge, and doing so quickly only increases the difficulty. INTERA is developing a groundwater flow and transport model for permitting, management, and performance assessment of the injection barrier at the Alamitos Gap for the Orange County Water District (OCWD), the Water Replenishment District of Southern California, and the Los Angeles Department of Public Works (LACDPW). Erosion and deposition on an uplifted transgression-regression system of aquitards and aquifers created pathways for seawater to travel inland. The pathways, called mergence zones, connect the seawater-intruded Recent Aquifer with the deeper aquifers used to supply water to a large population and so were critical to a successful hydrogeologic framework. Data sources included well logs with picks made using differing nomenclatures, structure contours from another consultant, mergence zone maps, geophysical logs, and MODFLOW files for the larger-scale Orange County flow model. A regulatory deadline allowed five months to complete the model. INTERA created a consistent well data set by correlating aquifers previously interpreted by LACDPW workers to aquifers designated by OCWD staff from more recent geophysical logs and cross-correlating units from different nomenclatures. INTERA then extended the hydrogeologic framework beyond and below previous frameworks by testing and integrating the disparate data using a combination of traditional geologic interpretation, GIS analysis, and an innovative geologic modeling software tool. The hydrogeologic framework, with accurate mergence zones, was completed in time to build and calibrate the flow and transport model to meet the regulatory deadline.

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Transport of Nitrate and Chloride in Saturated Soil Columns

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Presentation Abstract 20

Nitrate, an important nitrogenous compound in fertilizers, is of environmental concern with regard to groundwater contamination. Nitrate is weakly adsorbed by soils and could move quickly through the soil profile leading to plant nutrient loss and groundwater pollution. The purpose of this research was to evaluate the transport processes during individual and coupled transport of nitrate and chloride through 10 cm long soil columns packed with sand and loam soils under four different pore water velocities. A pulse of 200 mL of 0.1 M calcium nitrate, calcium chloride and 1:1 calcium nitrate/calcium chloride mixture solutions was applied from bottom through saturated columns. The chloride and nitrate concentrations in the effluent solution were determined using standard laboratory procedures and the CXTFIT program was used to determine the two region non-equilibrium transport model (TRM) parameters. The measured breakthrough curves in columns packed with loam were mostly symmetric while those from sand were asymmetric. Most of the TRM parameters increased with pore water velocity for both soil columns. Nitrate and chloride exhibited similar transport behavior patterns for both porous media and no differences were observed between their individual and coupled transport.

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Changing Rules Both Facilitate and Impede Water Independence

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Presentation Abstract 21

New Mexico continues to face a projected shortfall between water supply and water demand. Last year I discussed some of the institutional obstacles to implementing conservation and developing new water resources. Although many of those obstacles continue to be important, we also are seeing significant changes in the rules that apply to water policy in New Mexico.

It is important to understand the rules that have recently changed (mainly by court action) and the rules that are likely to change in the near future. Many proposals for improving the water situation of New Mexico may not be feasible because they are inconsistent with the changing rules. Many of the rule changes impact the way we need to interpret terminology that is often used without fully understanding the way that terminology needs to be interpreted to be consistent with the changing rules.

Trying to do water planning without a full understanding of the changes in the rules is like attempting to file taxes for 2010 using 2008 tax rules or planning strategy for a sporting event using the rules in existence from a prior year. Some of the rule changes discussed will be those impacting Public Welfare, Conservation, Water Right Permits, Interstate River Compacts, Water Rights Settlements, Water Rights Adjudications, Dedications, State and Federal Ownership of Water Rights, Restrictions on Inter-Basin or Interstate Water Transfers and other terms which we may think we know what they mean, but which have recently changed their meaning or will likely do so in the near future.

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Conjunctive Use of Surface and Groundwater in the Southern Española Basin, Santa Fe County, New Mexico

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Presentation Abstract 22

Santa Fe County, along with the City of Santa Fe, has embarked on a major surface diversion project on the Rio Grande known as the Buckman Direct Diversion (BDD) Project. Instead of relying solely on local water resources within the Santa Fe area of the Southern Espanola Basin, the use of San Juan-Chama Project water and native Rio Grande water from the BDD will preserve these water resources.

Although water from the BDD will provide additional supplies from a historically reliable source (the Rio Grande) and will lessen the demand on local supplies, it is recognized that surface flows on the Rio Grande can be variable and there may be times of inoperation of the diversion structure or treatment system. By utilizing groundwater solely as a back-up, the key benefits are protection of local water resources, reliability of supply, optimization of public assets through a proposed 10 year moving average and benefits to other water rights holders in the basin.

Currently Santa Fe County is implementing this Conjunctive Management Strategy by selecting back-up well locations utilizing a map based sensitivity analysis which ranks environmental factors, location of existing wells, hydrogeology and areas of contamination. In highly ranked areas further modeling to estimate drawdown and surface water impacts was performed to compare favorable areas.

A five member Water Focus Group, consisting of water stakeholders in the basin, was formed to review the sensitivity analysis and give a recommendation to the Board of County Commissioners. This form of public input has been successful and should lessen transaction costs when Santa Fe County seeks a permit from the Office of the State Engineer.

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Removal of Uranium, Arsenic and Fluoride from Impaired Groundwater Using Membrane Distillation Process

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Presentation Abstract 23

Ground water, in many parts of the world, is being polluted by hazardous contaminants due to various ecological factors which are both natural and anthropogenic. In some cases, the salinity in the groundwater is very high which renders it unsuitable for most potable uses. Membrane distillation process can be employed to recover saline ground waters polluted with hazardous contaminants with minimal energy consumption. The process operates at temperatures in the range of 50-80^{o}C and produces high quality permeate, free of hazardous compounds. In this study, the feasibility of the direct contact membrane distillation (DCMD) process to recover arsenic, uranium and fluoride contaminated brackish waters was investigated. Two types of membranes (Polypropelene, PP; and Polytetrafluoroethylene, PTFE) were tested to compare the permeate production rates and removal efficiencies. Several experiments were conducted to study the effect of salts, arsenic, fluoride and uranium concentrations (synthetic brackish water with salts: 1000-10000 ppm; arsenic and uranium: 10, 40, 100, 400 ppb; Fluoride: 1, 5, 10, 30 ppm) on the desalination efficiency. Also, the effect of process variables such as feed flow rate, feed temperature and pore size was investigated. The experimental results proved that the DCMD process was able to achieve over 99% rejection of the salts and arsenic, fluoride and uranium contaminants and produced high quality permeate suitable for many beneficial uses. The ability to utilize the low grade heat sources makes the DCMD process a viable option to recover potable water from variety of impaired waters in rural areas.

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The Use of Numerical Models in the Decision-Making Process

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Presentation Abstract 24

Management of the water supply of the middle Rio Grande (MRG) basin in New Mexico is highly constrained by its variability and existing laws and regulations that govern downstream water deliveries to the state of Texas at Elephant Butte Reservoir. These constraints make the decision making process difficult to develop without a comprehensive hydrologic modeling framework. Therefore, several hydrologic models have been developed to assist in evaluating alternatives. The Upper Rio Grande Water Operation Model (URGWOM) is one of the comprehensive tools that is being used in the decision making process. URGWOM is based on RiverWare, which is a reservoir and river basin simulation and optimization modeling platform, and extends from the northern reaches of the basin in southern Colorado to Elephant Butte Reservoir in southern New Mexico. Most recently it was used to develop a decision regarding the relinquishment to Texas of a portion of New Mexico's accrued credit water in Elephant Butte Reservoir. Under the Rio Grande Compact, when New Mexico delivers more water to Elephant Butte Reservoir than is required, it accrues credit. New Mexico may relinquish such accrued credit water to Texas in subsequent years. New Mexico started this year (2010) with 180,500 af of credit water and with Article VII of the Rio Grande Compact in effect. When Article VII is in effect, neither Colorado nor New Mexico may increase storage in reservoirs in the Rio Grande basin upstream of Elephant Butte Reservoir which were constructed after 1929. In early spring 2010, the water supply for Rio Grande Project agricultural lands below Elephant Butte Reservoir was less than 30 percent of full supply. Given these conditions and the water supply forecast, the state of New Mexico decided to relinquish a portion of its credit water to benefit water users both upstream and downstream of Elephant Butte Reservoir. The decision involved how much water to relinquish and the date of relinquishment in order to optimize upstream storage and provide additional water to the Rio Grande Project. Three different amount and dates were used to develop nine possible alternatives. These alternatives were evaluated using URGWOM against several criteria such as: the amount of storage projected to be captured at El Vado Reservoir on the Rio Chama in northern New Mexico, Rio Grande Project supply and the date when article VII would go out of effect. The final decision variables were different than the simulated, however, these provided decision-making guidance given the high variability in system constraints.

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Climate Change Impact on Streamflow, Bosque Del Apache

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Presentation Abstract 25

Bosque Del Apache National Wildlife Refuge provides habitat for diverse wildlife along the Middle Rio Grande. Various migratory birds flock in every November and stay through the winter, making the area one of the national prime bird-watching locations. Bosque Del Apache in the summer is an oasis with extensive wetlands, farmlands, and riparian forests surrounded by desert landscapes. Altered temperature and precipitation associated with future climate change scenarios will impact the average annual flow through the refuge.

To estimate future streamflow through the refuge, previous results of estimated streamflow from eight Rio Grande tributary watersheds were used along with historic information for San Acacia and San Marcial. Two different statistical methods are used resulting in average monthly values of flow for different climate change scenarios.

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Development of a Water Quality Modeling Tool for Evaluation of Lower Rio Grande Salinity Management Alternatives

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Presentation Abstract 26

Salinity modeling tools are needed for the Rio Grande Project Salinity Management Coalition Program to evaluate salinity management alternatives from San Acacia, New Mexico to Fort Quitman, Texas. A regional-scale model can be used to predict how the system will respond to upstream changes in salinity and to assess the salt balance for the study area, while a finer-scale model would assist in providing an understanding for a site specific system and hydrogeology. A simple solute mixing model is being developed to address the regional-scale salinity modeling needs. The model is built in conjunction with the Lower Rio Grande RiverWare surface water flow model. The solute mixing model adopts the RiverWare model output as the basic input parameters for the flow and system framework while it combines geochemical data to simulate the movement and changes of solutes in the system. The advantage of using the LRG RiverWare model results to build the water quality model is that the RiverWare model is not only providing the stream flow dynamic scheme in a monthly step but also simulating the interactions between the surface water system and the shallow aquifer system in a reasonable fashion. As a result, this solute mixing model has incorporated both surface water and groundwater components, and can be easily used to assess how the Rio Grande system will respond to surface water and groundwater changes in salinity. The model is currently being developed for the reach from below Caballo Reservoir, New Mexico to El Paso, Texas.

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Spatial Variability of Soil Hydraulic Properties in Agricultural Fields of Southern New Mexico: Implication on Irrigation Management

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Presentation Abstract 27

Estimating spatial variability of soil physical and chemical properties is a prerequisite for soil and crop specific management. The objectives of this study were to determine the degree of spatial variability and variance structure of soil physical and chemical properties on a 40-ha agricultural land of Plant Science Research Center of NMSU, Las Cruces, NM and utilize it for better irrigation management. Soil bulk samples (n = 572) were collected during Nov. 2008 and Nov. 2009, and soil core samples (n = 286) were obtained during Nov, 2009 from 0-15 cm depth. 151 samples were collected at the center of a regular grid of 50 × 50 m and 135 were obtained on the grid line at a mean separation distance of 6.75 m. The software package GS+ (Gamma Design Software, Plainwell, MI) was used to model the variance structure of soil bulk density (ρ_b), saturated hydraulic conductivity (*Ks*), pH, electrical conductivity (EC), nitrate-N (NO_3- N), chloride (Cl), and volumetric water content (θ) at pressure potentials (Ψ_a) (-33, and -1500 kPa). The coefficient of variation (CV) ranged from 4% (pH) to 141% (*Ks*). The *Ks* was found highly correlated to ρ_b (r = 0.88) as well as θ at field capacity (FC) (r = - 0.75) and wilting point (WP) (r = - 0.73). The semivariograms showed that range varied from 33 m to 695 m for all measured soil properties. Correlograms with Moran's I, indicated a distance of 135 m was sufficient to yield independent samples for measured soil properties. The kriged contour maps of *Ks* and FC along with their spatial structure can be used in making better sampling designs and irrigation management decisions.

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Impacts of Salinity on Growth of Marine Microalgae Nannochloropsis and Invaders in Biodiesel Production Systems

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Presentation Abstract 28

Microalgae are capable of producing lipid, which in turn can be turned into biodiesel. Microalgal biodiesel has notable advantages over current crop-derived biofuels: microalgae, such as marine Nannochloropsis salina, do not require arable land or high quality water; have higher growth rates and yields; require lower nutritional inputs; and can be cultivated continuously rather than in a seasonal mode. New Mexico's areas of arid land and availability of salt water creates an ideal location for leading the nation in microalgal biodiesel research. Concerning potential risks to open pond cultures include invasion of predators, competitors and pathogens, but may be minimized through the manipulation of salinity, pH, and nutrient levels. Preliminary experiments conducted indoors using a wide range of salinities (0-204 ppt) identified the ability of Nannochloropsis to grow in salinities from 0-68 ppt. Cell densities after 3 weeks ranged from 350 cells/µL to 5025 cells/µL (0 and 25 ppt, respectively). Sensitivity of Nannochloropsis to salinity was examined utilizing two strains of the species (CCMP 1776 and CCMP 1779) cultivated in five salinity treatments (10, 22, 34, 46, and 58 ppt), with six replicates of each salinity, totaling sixty treatments. Algae are growing fastest at 22 ppt but the cultures are most resistant to invaders at 58 ppt.

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Spatial Variability of Infiltration Rate and Soil Chemical Properties of Desert Soils: Implications for Management of Irrigation Using Treated Wastewater

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Presentation Abstract 29

Knowledge of soil infiltration rate, their spatial variability and relation to soil chemical properties is very crucial for the land management decisions affected by anthropogenic activities. In situ infiltration tests were conducted at West Mesa land application site to determine the spatial variability of infiltration rate using tension infiltrometer and suggest suitable management strategy to reduce the detrimental effect to the soil and plant environment. Infiltration tests were conducted in 50 x 50 m grid spacing at -5, -10, -20, and -30 cm tensions during March-April 2009. Each test was conducted for an hour in the surface soil at 74 grid locations. Bulk soil samples were also collected from each grid locations at 0-20 cm depth to determine sodium (Na^+) before the infiltration test. Woodings's (1968) equation was used to calculate saturated (Ks) and unsaturated hydraulic conductivity (Kunsat -5,-10,-20,-30) from the steady state infiltration rate (Is). Study area was divided into five classes with Ks increasing from class I to V; class I contained $Ks \leq 5$ cm/h, class II $5.1 < Ks \leq 10$ cm/h, class III $10 < Ks \leq 15$ cm/h, class IV $15.1 < Ks \leq 20$ cm/h and, class V $Ks > 20$ cm/h. Coefficient of variation (CV) showed that different Ks classes were low to moderately variable and semivariogram displayed both short and long range variability. Ks kriged map showed classes I, II and III were concentrated at northeast and southwest side of the study plot where higher Na^+ was detected and IV and V were at the center of the study plot where lower Na^+ level was detected. It is necessary to change the wastewater application pattern as well as reduce the level of Na^+ in the applied wastewater.

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Polyphosphate Accumulating Organisms in Activated Sludge: Biokinetics and Competition for Carbon

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Presentation Abstract 30

Enhanced biological phosphorus removal (EBPR) is a popular modification of the activated sludge process, in which anaerobic/aerobic cycling of biomass enriches polyphosphate accumulating organisms (PAOs), which are responsible for high levels of phosphorus removal from wastewater. Many fundamental aspects of EBPR are still not well understood. Glycogen accumulating organisms (GAOs) compete with PAOs for volatile fatty acids such as acetate during the anaerobic phase of the treatment process, which is thought to lead to deterioration of EBPR, so improving our understanding the kinetics of substrate uptake by PAOs and GAOs may be helpful to develop process control strategies to ensure EBPR. Previous research has suggested that GAOs utilize less energy for acetate than do PAOs, so it was hypothesized that GAOs may benefit from higher acetate concentrations, which would facilitate low energy transport mechanisms, while PAOs may be better at taking up acetate at lower concentrations. Because PAOs release phosphorus during anaerobic acetate uptake and GAOs do not, higher phosphorus release/acetate values indicate greater amounts of PAO activity relative to GAO activity. A series of batch tests were performed on activated sludge taken from a bench scale EBPR reactor to evaluate our hypothesis. Acetate was added either as a pulse, which produced high initial concentrations that decreased over time, or with a syringe pump, which added acetate slowly and continuously, and results in overall low acetate concentrations. In both cases, the experimental data supported the hypothesis that PAOs have kinetic advantage at low acetate concentration by yielding higher ratios of anaerobic P release to acetate uptake at lower acetate concentrations, thus indicating that PAO activity increased relative to GAO activity at lower acetate concentrations. This is an important result, since acetate concentrations are generally low in full scale wastewater treatment plants, which suggests that GAO competition may be less important than previously thought. Future investigations will include identification of bacteria using molecular methods and application of different inhibitors to target different membrane proteins, which will help provide a clearer understanding of PAO and GAO biokinetics and competition.

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Desalination Using Solar Energy: Towards Sustainability

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Presentation Abstract 31

This paper describes the theoretical rationale for a new low-temperature phase-change desalination process, and six examples of applications to illustrate how this process can be engineered for sustainable desalination. In this process, brackish water is evaporated at near-ambient temperatures under near-vacuum pressures created by the barometric head without any mechanical energy input. The thermodynamic advantages and benefits of low temperature phase-change desalination are discussed and results from simulation studies and a prototype test system are presented. Three of the examples illustrate how the proposed process can be driven by solar energy: a) utilizing direct solar energy; b) inclusion of an external reflector; c) utilizing photovoltaic energy during non-sunlight hours. The other examples illustrate how the proposed process can be driven by waste heat: a) waste heat rejected by an absorption refrigeration unit driven by grid power; b) waste heat rejected by an absorption refrigeration unit driven by solar collectors; and c) waste heat rejected by an absorption refrigeration unit supported by a photovoltaic array. Merits of utilizing solar energy and process waste heat in reducing energy consumption and green house gas emissions are discussed in detail.

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Aqueous Geochemistry and Environmental Fate of Uranium in the Española Basin, New Mexico

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Presentation Abstract 32

Uranium is an actinide of considerable interest in environmental geochemistry studies conducted within the Española Basin, New Mexico. The regional aquifer within the Española Basin contains highly variable background concentrations of total dissolved uranium ranging from 0.002 to 7.6 micromolar. Numerous volcanic glass deposits in various stages of alteration contain roll-front uranium(VI) ore bodies east of the Rio Grande between the cities of Santa Fe and Española. The regional aquifer typically is oxidizing with respect to uranium, sulfur, and nitrogen, and contains measurable concentrations of dissolved oxygen greater than 0.03 millimolar. The regional aquifer consists of calcium-sodium-bicarbonate, sodium-calcium-bicarbonate, and mixed major ion compositions with bicarbonate concentrations commonly exceeding 3.3 millimolar. Uranyl carbonate complexes are predicted to dominate in regional aquifer groundwater. Concentrations of natural reductants including hydrogen sulfide and dissolved organic carbon are not sufficient to enhance stability of uranium(IV) aqueous complexes and solid phases in the regional aquifer. Background distributions of total dissolved uranium are believed to be controlled by precipitation of uranium(VI) minerals, specific adsorption of uranium(VI) complexes onto hydrous ferric oxide, and cation exchange of uranyl cation with calcium in smectite. The regional aquifer shows variable saturation with respect to soddyite and approaches saturation with respect to haiweeite depending on pH and the activities of calcium and silica. Elevated above-background concentrations of dissolved uranium (maximum of 0.025 micromolar) occur in the regional aquifer downgradient from Los Alamos National Laboratory outfalls. Laboratory uranium contamination in groundwater is limited to west of the Rio Grande.

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Environmental Tracers in Groundwater of the Salt Basin, NM, and Implications for Water Resources

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Presentation Abstract 33

The Salt Basin in Southern New Mexico is an example of an aquifer system that experiences extensive pumping, primarily for agricultural purposes, while the recharge rates and storage capacity of the area are not fully understood. A regional scale, integrated, conceptual model of the Salt Basin groundwater system is still lacking. The Salt Basin is a carbonate aquifer where fracture patterns and dissolution features play a dominant role in groundwater movement. Due to the high degree of natural variability in permeability and other hydrologic properties, basin scale hydrodynamics of the system were characterized with the use of environmental tracers. These are naturally present in the groundwater system and can illustrate integrated hydrologic behavior along flow paths. In this study, a suite of environmental tracers are being quantified in the Salt Basin groundwater system to obtain information on sources of recharge, estimates of recharge rates, flow paths, flow rates, and sources of solutes in the groundwater. With estimates for flow velocity and porosity a groundwater flux can be calculated across a given subsurface cross-section which is related to the recharge flux entering the Salt Basin along primary flow paths. This characterization of the Salt Basin groundwater system can then be applied to water management, controls on water quality, and protection of the groundwater from contamination sources.

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Landscape Consumptive Water Use Estimation
Which Method to Use and Why?

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Presentation Abstract 34

"When the well is dry, we know the worth of water."
- Benjamin Franklin (1706-1790), Poor Richard's Almanac, 1746

As populations in our arid and semi-arid southwestern and inter-mountain states increase, it is critical that we preserve or conserve our water resources. To be able to confidently manage our water resources, it is vital that we be able to quantify key components of a local or regional water budget. On the demand side of the water budget, consumptive use by vegetation often represents a major component of the overall budget, be it crop consumptive use in agricultural areas, or outside landscaping consumptive use in municipal and suburban areas. Two of the consumptive use (evapotranspiration) estimation methods most frequently used for the above applications are: the Original/Modified Blaney-Criddle method (OBC/MBC) and the standardized American Society of Civil Engineers- Penman Monteith (ASCE-PM) reference method. The OBC method was developed using experimental and field data collected in the Southwestern states, and therefore, some authorities recommend using this method for crop consumptive water use estimation in the Southwestern states. The latter approach, ASCE-PM reference method, is widely used not only in the USA, but also in many other countries. Reason for this preference is the physical soundness of the method. However, the ASCE-PM method requires numerous weather data inputs, several of which are not collected at all weather stations, and both methods utilize empirical coefficients to estimate crop water use in their final part of calculation. In this paper, we evaluate the consumptive use of the outdoor landscaping on the New Mexico Tech campus in Socorro, including the golf course, using both the OBC and ASCE – PM methods for a 40-year period of record. In implementing these approaches, we employ two distinct climate models for developing the meteorological data needed as input to the evapotranspiration methods. The first model is the PRISM (Parameter-elevation regressions on Independent Slopes Model) climate model, and the second model is the Maurer et al. (2002) climate model.

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PRESENTATION ABSTRACT 35
WITHDRAWN

Applying Distributed Temperature Sensing (DTS) to New Mexico Climate Change Research

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Presentation Abstract 36

Raman-spectra distributed temperature sensing (DTS) uses inexpensive fiber optic cable to provide high-resolution (meter-scale) temperature measurements over distances up to several kilometers. After years of use in pipeline monitoring and fire detection, DTS has recently also emerged as a powerful tool in environmental sensing. As part of the NSF-funded project, NM EPSCoR RII3 (Climate Change Impacts on New Mexico's Mountain Sources of Water), DTS technology is being deployed in the East Fork Jemez River of the Valles Caldera and in the Rio Hondo near Taos. These tributaries are critical to water supply to the Rio Grande and their watersheds have the potential to be severely affected by climate change. Using water temperature differences to monitor stream and groundwater interactions, DTS technology provides the high-resolution monitoring needed to inform hydrologic models. This leads to a better understanding of the hydrology of these areas and therefore, the potential impacts of climate change on water supply to the Rio Grande.

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Water Resources Assessment of the Cimarron River and Evaluation of Water Quality Characteristics at the Maxwell National Wildlife Refuge

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Presentation Abstract 37

In June 2010, students from the UNM Water Resources Program conducted an intensive study of the Cimarron River watershed in New Mexico from its headwaters to its confluence with the Canadian River. The group also examined the Maxwell National Wildlife Refuge (NWR) near Maxwell, NM. The main objective of the study was to assess the physical and chemical characteristics of the Cimarron River and evaluate water quality and playa lake sediment chemistry at the wildlife refuge.

The assessment included measurement of flow and water quality at 34 surface water sites in the two study areas. Additionally, six reaches of the Cimarron River and one reach of Rayado Creek were evaluated using EPA's Environmental Monitoring Assessment Program (EMAP) protocol. Data concerning hydrology, water quality, geomorphology, riparian vegetation, benthic macroinvertebrates, and human impacts were collected and analyzed both in the field and at the University of New Mexico.

This assessment found generally high quality conditions of the river and riparian environment throughout the Cimarron River watershed. The water quality in lakes and irrigation ditches at the Maxwell NWR was also of generally high quality. Salt deposits on dry playa lake sediments were found to be dominated by calcium, magnesium and sodium sulfates. Screening analyses were performed for a suite of transition metals and none were found at environmentally relevant concentrations. Trace level analyses were also performed for arsenic and selenium. A particular value of this study is that it serves as a baseline for quantifying the benefits of current watershed restoration activities. It will also serve as a reference point for future investigations, especially those of longer duration that can monitor seasonal characteristics within the watershed.

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Water Fluxes in the Unsaturated Zone of a Mature Pecan Orchard in Arid Southern New Mexico

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Presentation Abstract 38

Information is still limited about the coupled liquid water, water vapor and heat transport associated with transient variations of soil water content and temperature in the unsaturated soil of irrigated pecan orchard grown under arid climate of southern New Mexico. The field experiment was carried out at a private pecan orchard in Las Cruces, New Mexico. Three pecan trees were chosen to monitor diurnal soil water content under the canopy (approximately half way between trunk and the drip line) and outside the drip line (bare spot) along a transect at the depths of 5, 10, 20, 40, 60 and 80 cm using TDR sensors. TDR calibration at each sensor depth was found to fit the gravimetrically determined water content data. Soil temperature sensors were installed under the canopy and at bare spot to monitor soil temperature data at the depths of 5, 10, 20, and 40 cm. The simulation model HYDRUS-1D was previously calibrated and validated under arable field conditions planted to onions. We are attempting to apply HYDRUS-1D to mature pecans to evaluate various transport mechanisms associated with temporal variations in soil water content and soil temperature in the 0-40 cm unsaturated zone within canopy and bare spot. The model will be applied using measured soil water content and soil temperature at 5, 10, 20, and 40 cm. Measured soil hydraulic and thermal properties, and meteorological data will be used in model simulations. The research will provide quantitative estimates of water vapor fluxes within and outside the canopy.

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Relation between Fractional Canopy Cover and Crop Coefficient in Pecan Orchards based on Orchard Floor Photographic Imagery

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Presentation Abstract 39

Crop water use as basal crop coefficient (Kcb) and crop coefficient (Kc) can be determined from reference and actual evapotranspiration. These coefficients are specific to a crop under given growing conditions. Recent research has illustrated that plant and tree canopy cover is correlated to its corresponding Kc. Therefore, an easier way to estimate the Kc could be to estimate the coincidence fractional canopy cover (FC) and then develop a model to estimate Kc directly from estimated FC. We propose that analysis of orchard floor photographs under sunny conditions can yield FC. For this purpose, 4 auto-photographer regular digital cameras with 1.3 M Pixel resolution were installed inside the pecan orchard of the Leyendecker Plant Science Research Center, Mesilla Valley, NM. They were set up to take daily floor photos during the peak time of the growing season, May 13th to July 30th. Image processing techniques, using the software package Environment for Visualizing Images (ENVI 4.6.1) software, was applied to extract the mid-day FC of pecan trees in this orchard. Also, the soil structure of eight orchards including Leyendecker, was studied to aid in the Kc calculation. The results of this study showing the relationship between FC and Kc will be presented. If successful, this technique may improve the estimation of Kc for pecan orchards based on a rapid method using orchard floor photos.

Key Words: basal crop coefficient (Kcb), crop coefficient (Kc), reference and actual evapotranspiration, floor photo, image processing

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Expansion of the Sanitary Effluent Reclamation Facility (SERF) at Los Alamos National Laboratory: Reducing, Reusing and Recycling Potable Water at LANL

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Presentation Abstract 40

The Sanitary Effluent Reclamation Facility was originally developed as part of a system designed to reduce the mining of groundwater from the regional aquifer via reclamation, treatment and reuse of sanitary wastewater in cooling towers supporting the Super-Computing Complex at LANL. The SERF process has been proven to substantially reduce or completely remove unwanted constituents from effluents destined to be discharged into the environment via Sandia Canyon. The SERF process has been proven to reduce PCBs in sanitary wastewater from ~3,000 picograms/liter (2,300 x 10-12 grams/liter) to less than the discharge limit of 640 picograms/liter (640 x 10-12 grams/liter). Other chemical constituents in the SERF product water are also expected to meet stringent NPDES permit discharge limits. Implementation of an expanded SERF could reduce annual potable water consumption at LANL by ~120,000,000 gallons of water, or more. The reuse of sanitary wastewater in cooling towers at LANL, via expansion of the SERF and connecting to the hydronic systems it would support, could reduce discharges of wastewater effluent into Sandia Canyon up to 120 million gallons of water (MGY) annually, or more. The reuse of ~120 MGY of sanitary effluent represents a savings of approximately 32% of the potable water consumed at the entire LANL complex during 2008.

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