FARM SIZE, IRRIGATION PRACTICES, AND ON-FARM IRRIGATION EFFICIENCY IN NEW MEXICO'S ELEPHANT BUTTE IRRIGATION DISTRICT

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Poster Abstract 1

Relationships between farm size, irrigation practices, and on-farm irrigation efficiency in the Elephant Butte Irrigation District, New Mexico, are explored using water delivery data supplied by the District. The study area is experiencing rapid population growth, development, and competition for existing water supplies. It is assumed that water will ultimately be transferred from agriculture to other uses. Analysis of pecan, alfalfa, and cotton water delivery data, fieldwork, and interviews with irrigators found extremely long irrigation durations, inefficient irrigation practices, inadequate on-farm infrastructure, and lack of interest in making improvements to the current irrigation system or methods on the smallest farms.

These findings are attributed to the nature of residential, lifestyle, or retirement agriculture. Irrigation practices on large, commercial farms are notably different from the smallest farms: irrigation event durations are shorter, less water is applied, and the producers are commercially oriented. With respect to future increases in the efficiency of irrigation water usage, large, commercially oriented producers already have achieved a high level of physical efficiency.

Many small producers appear to view irrigation as a consumptive, recreational, social, or lifestyle activity, rather than an income generating pursuit, thus the cost of inducing changes in their practices may be extremely high. Small farm operators are likely to show limited interest in improving on-farm irrigation infrastructure, adopting management intensive irrigation technologies or practices, or making significant irrigation investments. Easement and common property disputes over ditch maintenance between owners of small parcels also create disincentives for infrastructure improvements.

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ESTIMATING CROP EVAPOTRANSPIRATION FROM SATELLITES: REGIONAL ET ESTIMATION MODEL (REEM)

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Poster Abstract 2

Crop evapotranspiration (ET) is a major component of the hydrologic system. The ET values are used in irrigation water management, water right allocation, hydrological modeling and water resource planning and management. Traditionally, ET has been estimated using crop coefficient and climatic parameters. Point measurement of ET can also be made through soil moisture monitoring, vapor flux measurement or energy balance using the eddy-covariance method. However, traditional methods will only provide point measurements of ET and does not account for spatial variability of ET in large scale. Recent advances in remote sensing have made it possible to develop regional maps of ET with high precision.

A procedure was developed to use the combination of satellite data, ground level weather stations and point measurements of ET, to estimate and develop regional ET maps. The Regional ET Estimation Model (REEM) is based on energy balance at the crop canopy. The model uses incidental values of NDVI, near infrared temperature and albedo, from satellites to calibrate the sensible heat flux equation. The sensible heat flux equation is calculated daily and is modified spatially using well defined nodes in the watershed based on an optimization technique. The REEM based ET values were compared with direct measurement of ET in Pecan in Southern New Mexico. The comparison showed that the crop ET can be calculated from REEM model with high precision.

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ECOHYDROLOGICAL MODELING OF GRASSLAND-SHRUB-TREE DYNAMICS IN THE SEVILLETA NATIONAL WILDLIFE REFUGE

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Poster Abstract 3

Arid and semi-arid regions are extremely diverse in terms of their geology, topography and ecosystems. Since water availability is a dominant factor in these systems, obtaining accurate information of the water balance parameters is significant for understanding the interaction between the land surface and atmosphere over a range of space and time scales. The objective of this study is to apply simple analytical water-balance model introduced by Laio et al. (2001) to investigate the relationship between the hydrogeologic parameters (soil, vegetation and precipitation) and the soil moisture, runoff, deep percolation and evapotranspiration in the Sevilleta National Wildlife Refuge (SNWR). We apply the stochastic soil moisture model over the SNWR region by assuming an independent set of grid cells to obtain the spatial pattern of the water balance components. Historical daily rainfall data (1990 – 2003) were used at six different rain gauge sites in the area. Soil and vegetation types have been generalized into a reduced number of general classes in order to obtain eighty-one (81) different combinations. The effect of different types of soil, vegetation and amount/distribution of precipitation on soil moisture and other water balance parameters will be addressed. The relative importance of soil and vegetation properties will be evaluated in the context of point and spatial hydrologic output. From the model results, we will infer how the interaction between climate, soils and vegetation leads to the co-existence of grasses, shrubs and trees in the region. Finally, the limitations of the model and possible extensions will be examined.

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QUANTIFYING NUTRIENT SOURCES AND CYCLING ALONG THE UPPER RIO GRANDE

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Poster Abstract 4

Water quality often limits the potential uses of scarce water resources in semiarid and arid regions. To best manage water quality one must understand the sources and sinks of both solutes and water to the river system. To address this issue we have performed winter and summer synoptic sampling of the Rio Grande from Del Norte, CO to Fort Quitman, TX since January of 2000. The initial focus was identifying salinity sources using solute ratios and ^{36}Cl, $^{87}Sr/^{86}Sr$, and d34S. In the summer of 2001 the scope of work was expanded to investigate nutrient sources and cycling. To date the sampling has demonstrated that the water quality, both salinity and nutrient concentrations, degrades with distance downstream. Dissolved Organic Carbon (DOC) concentrations gradually increase with distance downstream, but inorganic nitrogen concentrations are more variable due to localized surface water inputs both from agricultural and urban/wastewater sources. Below these localized inputs ammonium is quickly removed or converted to other N species in the river during both summer and winter whereas nitrate concentrations decrease more slowly. Exchange between surface water, hyporheic zone, and riparian corridor results in the net removal of nitrate from the river.

Samples collected this June indicate that the agricultural drains in the Middle Rio Grande have lower concentrations of nitrate and phosphate than the Rio Grande and similar to slightly lower concentrations of ammonium and DOC than the river suggesting that agricultural diversions are not a significant source of nutrients to the river in this region. Future research will include quantifying nutrient loading, transport distance and uptake length within different river reaches.

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A SUMMARIZED REVIEW OF SELECTED HYDROLOGIC CHARACTERISICS OF THE WHITE SANDS PUPFISH (*Cyprinodon tularosa*) HABITATS, TULAROSA BASIN, NEW MEXICO

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Poster Abstract 5

This poster summarizes selected hydrologic characteristics of the White Sands pupfish (*Cyprinodon tularosa*) habitats in the Tularosa Basin. The study area is located in the northern part of the Tularosa Basin in south-central New Mexico in Lincoln, Otero, Sierra, and Socorro Counties. The White Sands pupfish currently (2004) inhabit four locations: Salt Creek, Main Mound Spring, and Malpais Spring/Salt Marsh in White Sands Missile Range and Malone Draw/Lost River in Holloman Air Force Base. Information used to characterize pupfish habitats included daily and instantaneous streamflow, a seepage run (gain-loss study), suspended sediment data, and physical and chemical water-quality data. The data were compiled from the U.S. Geological Survey National Water Information System database, other published and unpublished U.S. Geological Survey data, and a report published in 1987 by the Department of Fishery and Wildlife Sciences, New Mexico State University. These data (through September 2002) are being assembled for a U.S. Geological Survey publication.

The hydrologic data illustrate that the White Sands pupfish can survive in and adapt to a variety of water-quality conditions, including a large range of dissolved solids concentrations. Generally, the concentration of dissolved solids of the four habitats ranged from brackish to saline water. In Salt Creek and Lost River/Malone Draw, the concentration of dissolved solids ranged from brackish water through brine. The water-quality characteristics can change rapidly in response to precipitation and streamflow conditions. Dissolved solids concentrations can affect White Sands pupfish body morphology and populations of fish parasites and aquatic snails that can be associated with fish parasites.

The ongoing investigation of streamflow and water-quality conditions in habitats for the White Sands pupfish will help to evaluate current and future management and research activities, assess cumulative effects from military activities, and adhere to National Environmental Policy Act documentation with regard to habitat conservation and the White Sands pupfish.

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A HISTORICAL SUMMARY OF THE STUDY OF RUNOFF FROM A SMALL WATERSHED, WHITE SANDS MISSILE RANGE, DONA ANA COUNTY, NEW MEXICO

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Poster Abstract 6

In the spring of 1964, a small watershed (catchment) of undisturbed land surface was constructed northwest of the Post Headquarters at White Sands Missile Range in Doña Ana County, New Mexico. The purpose of this watershed was to determine the amount of surface-water runoff from different precipitation events in the area. The study lasted from 1964 until 1966. The results of this study, presented in a U.S. Geological Survey open-file report, are often referenced in numerous hydrologic studies and models in south-central New Mexico.

The small, undisturbed watershed was one of two watersheds constructed as part of a cooperative study between the U.S. Army at White Sands Missile Range, Esso Research and Engineering Company (the research affiliate of the Standard Oil Company-New Jersey), and the U.S. Geological Survey. The original purpose of this study was to determine the feasibility of a system to economically harvest surface-water runoff to recharge the aquifer near the Post Headquarters well field. This poster presents unpublished U.S. Army photographs of the project and summarizes three reports. The unpublished photographs are also useful to study vegetation changes over time.

The amount of surface-water runoff was dependent upon several variables, some of which were slope of the land surface, vegetation, soil characteristics, duration of rainfall, average intensity, ambient temperature, surface temperature, evaporation, and wind velocity. The amount of surface-water runoff from the natural watershed during the period of study was about 3 percent of the amount of precipitation per year.

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HEAT AS A TRACER TO INVESTIGATE GROUND-WATER/SURFACE-WATER INTERACTION

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Poster Abstract 7

Difficulties inherent in measuring ephemeral streamflows have created a need for alternative methods of characterizing streamflow in ephemeral channels; the use of heat as a tracer to determine the presence and duration of streamflow is one such alternative method. The diurnal variations of streambed sediment temperatures (at shallow depths below the streambed surface) are affected by a variety of hydrologic and meteorological conditions, including the presence or absence of streamflow, streamflow loss or gain, precipitation events, and cold fronts. These diurnal temperature variations may be interpreted to determine the presence and duration of streamflow through a variety of techniques, from simple visual inspection to the more advanced automated time-series analysis.

This poster presents the basic principles of the use of heat as a tracer to determine the presence and duration of streamflow in ephemeral channels. Methods of data collection and advantages of various interpretation techniques are reviewed. Theoretical simulations of various hydrologic and meteorological phenomena are presented and discussed. Examples and interpretations of streambed sediment temperature data are provided. Finally, recent applications of this method – which have been implemented by the Southwest Ground-Water Resources Program to investigate ground-water/surface-water interactions – are reviewed.

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STREAMFLOW AND INFILTRATION IN THE ARROYO HONDO, NORTH-CENTRAL, NEW MEXICO

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Poster Abstract 8

As part of the Southwest Ground-Water Resources Program, a 3-year study of streamflow and streambed infiltration was conducted in the Arroyo Hondo, north-central New Mexico. Data were collected from October 1999 through October 2002.

Empirical estimates of mean annual streamflow, derived from equations relying on basin characteristics (including annual precipitation, channel width, and watershed area), ranged from 77,000 to 410,000 cubic meters. Total annual streamflow in the Arroyo Hondo ranged from zero to 474,000 cubic meters during the study period. Temperature-based methods were used to (1) estimate the presence and duration of streamflow throughout the Arroyo Hondo and (2) to estimate streambed infiltration rates. A variably saturated, two-dimensional, heat transport model (VS2DH) was used to simulate streambed infiltration during streamflow events; the simulated event-average infiltration rate was 1.4 meters per day. Cumulative annual streambed infiltration was estimated from simulated streambed infiltration rates, channel widths, and the downstream extent of streamflow; cumulative annual streambed infiltration ranged from zero to 250,000 cubic meters. Snowmelt-induced streamflow events resulted in a larger total streamflow upstream from the mountain front and produced more streamflow downstream from the mountain front than monsoon events, indicating that snowmelt events are more likely to result in streambed infiltration than monsoon events.

Measured streamflow and estimates of cumulative streambed infiltration are lower than previous estimates of streamflow and of streambed infiltration for every year during the study period. Lower precipitation rates during this study period might account for the smaller measured streamflow and smaller estimates of cumulative streambed infiltration.

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WATER SALVAGE, EROSION, AND BANK STABILITY IN RELATION TO TAMARISK ERADICATION

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Poster Abstract 9

In situ tamarisk evapotranspiration (ET) is difficult to evaluate because it depends on many factors such as climate, depth to water table, soil moisture, soil chemistry, age, disease, etc. While initially introduced for erosion control, it has escaped cultivation and now grows in dense monotypic stands along riparian and flood plain habitats. It is well established that saltcedar water use via ET is significant. Nevertheless, to date we are aware of no data that substantiate gains in stream flows or aquifer storage due to saltcedar removal. Presumably, water that would have otherwise gone to saltcedar ET is returned to the river and shallow aquifer. The problem, of course, is that this simple hypothesis remains unproven when applied to a real river basin. With no data that substantiate gains in stream flow or aquifer storage after eradication, the question remains: where does the water go?

Although equally important, almost no attention has been paid to the potential for bank erosion once saltcedar is gone. This could lead to damage to reservoirs from excessive sediment loading. A risk assessment of erosion potential of a formerly canopied stream bank is crucial to restoration planning.

Quantifying hydrologic and sedimentation responses from invasive plant management is a critical research need. To understand the impact of invasive plant ET on water availability, models must evaluate ET influences on the entire hydrologic cycle throughout a given water basin and determine if long-term invasive plant removal and restoration efforts will decrease reservoir storage capacity through excessive sedimentation.

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SIMULATION-OPTIMIZATION APPROACH TO MANAGEMENT OF GROUND-WATER RESOURCES IN THE ALBUQUERQUE AREA, NEW MEXICO, THROUGH 2040

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Poster Abstract 10

The City of Albuquerque (COA) has adopted a water-supply strategy that calls for a transition in 2006 from complete reliance on ground water to primary reliance on surface water, supplemented by ground water. A simulation-optimization approach was used to investigate how the COA could distribute supplemental ground-water withdrawals among its municipal-supply wells between 2006 and 2040 to achieve certain management objectives for the river-aquifer system of the Middle Rio Grande Basin (MRGB).

A U.S. Geological Survey ground-water-flow model for the MRGB was used to simulate response of the aquifer system to unit stresses (ground-water withdrawals) applied in each of the 25 COA well fields. The resultant "response functions" provided important information on effects of ground-water withdrawals in different locations on the quantity of water depleted from aquifer storage, the quantity of leakage from the Rio Grande and associated ground-water drains, and the magnitude of water-level declines through time. The response functions were incorporated into five optimization models of varying management objectives and constraints. The optimization models were designed in a mathematical programming software package and solved with a linear approach. Results demonstrated that future use of an optimal distribution of ground-water withdrawal by the COA rather than the historical (non-optimal) distribution could achieve substantial changes to components of the river-aquifer system over the period of interest.

One of the modeled management objectives was to determine the distribution of ground-water withdrawal that would minimize overall depletion of water from aquifer storage through 2040 while limiting water-level decline in the aquifer to no more than 2.5 feet per year in any simulation-model cell. This model indicated that optimization of ground-water withdrawals could result in about 242,000 acre-feet greater recovery of water in aquifer storage than the non-optimal distribution—equivalent to more than 2 times the quantity of water supplied to COA customers in 2000.

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UPDATE ON HYDROLOGIC STUDIES IN THE SOUTHEASTERN ESPANOLA BASIN NEAR SANTA FE, NEW MEXICO

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Poster Abstract 11

The New Mexico OSE, the New Mexico Bureau of Geology, the USGS, and Santa Fe County are in the third year of studies of the southeastern Espanola Basin, Santa Fe County, NM. Efforts are focused on hydrogeologic mapping and flow model characterization, updating historic water level data, rescoping and establishing a regional monitoring well network, and reinterpretation of all data. Fieldwork in 2003 focused on water level measurement and detailed mapping northwest of Santa Fe. The focus for 2004 is the Ancha Formation and underlying Tesuque Formation south of the city. Three multilevel monitoring wells have been drilled up to 2500' deep. Results reveal stacked sand bodies, interstratified with silt and true clays. West dipping strata and faulting in the Tesuque formation appear to influence the regional potentiometric surface. In some cases drawdown appears to be strata-bound. We are examining assumptions about ground water flow between the Ancha and underlying Tesuque formations. Our latest work addresses the relationship of a discontinuous spring line from La Cienega to Cerrillos to ground water flow within all formations in the Santa Fe Embayment. We propose to reenter an abandoned oil test west of the city. The well penetrated 4000 feet of Santa Fe group. Porous sands below 3000 feet are indicated in geophysical logs and are the object for testing, water quality analysis, and future water level monitoring. These strata project back to the productive interval in the City well field. Future work includes targeted geochemical analyses and an integrated geophysical definition of the floor of the Tertiary aquifer system.

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WATER QUALITY ASSESSMENT WITHIN THE GALLINAS WATERSHED

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Poster Abstract 12

This research was conducted to evaluate water quality conditions within the Gallinas Watershed. The Gallinas River originates in Precambrian crystalline rocks of the southern Sangre de Cristo Mountains and flows southeast toward Paleozoic and Mesozoic strata of the Las Vegas basin. The Gallinas River is the primary source of water for Las Vegas, NM, providing 95% of its domestic water supply. Additional surface water is diverted to the Storrie Lake Water Project (SLWP) and divided among multiple users, including the Las Vegas National Wildlife Refuge (LVNWR), farmers, and ranchers.

Seven surface water samples were collected from the Gallinas River beginning in the upper headwaters and ending down stream of the Las Vegas wastewater treatment plant. Additional surface water samples were collected from Storrie and McCallister Lakes, two SLWP diversions. Representative indicator parameters Ca, Na, Cl, and SO_4 increase from 11.8-142, 4.5-92.3, 1.3-62.2, and 9.9-450 mg/l respectively from the headwaters to the lower river sites. Likewise, hardness, alkalinity, conductivity, and total dissolved solids are appreciably higher in the lower Gallinas River. These results demonstrate that water quality decreases as the percentage of developed land increases and as the percentage of exposed sedimentary rocks increases.

An interesting observation is the dramatic degradation in water quality at McCallister Lake, the largest surface water body at LVNWR. Data show elevated concentrations of Ca (402), Na (1165), Cl (678), SO_4 (3525) (mg/l) and conductivity (11,200 micromohs/cm). X-ray analysis identified thenardite, a sodium sulfate, precipitating along the shoreline during the summer and fall. This indicates localized zones of saturation for Na and SO_4 exist seasonally within the shallow lake. Ground water samples collected from seeps along the Gallinas River canyon and down gradient of McCallister Lake show all indicator parameters occur at concentrations intermediate between those of McCallister Lake and local domestic wells. These data suggest that water within the seeps is the blending of surface water that infiltrates from the lake and mixes with ground water before discharging to the lower Gallinas River. Further study of evaporation affects as well as anthropogenic and natural aquifer contributions to water quality are warranted to improve water management practices within the Gallinas Watershed.

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ARSENIC CONCENTRATIONS AND SOURCES IN THE GALLINAS WATERSHED

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Poster Abstract 13

This research study involves flow weighted monitoring of Total Recoverable Arsenic (TRA) concentrations during different hydrological periods in the Gallinas River of San Miguel Co, NM, as well as identifying potential sources of arsenic to the river. The Gallinas River provides about 95% of the water requirement to the 18,000 inhabitants of the City of Las Vegas, NM. TRA was analyzed by ICP-MS at three event-activated monitoring sites along the Gallinas River. The study hypothesize that elevated arsenic concentrations correlate with high flows, high turbidity and high Total Suspended Solids (TSS) and are caused by erosion of soils from the landscape to the surface water. During base flow, arsenic levels range from 0.33 ìg/L at Upper Gallinas (5 miles from the head waters at Elk mountain), 0.40 ìg/L at Montezuma (near the City drinking water treatment plant diversion), to 2.49 ìg/L at Lower Gallinas just below the City. During storm events, levels as high as 0.87 ìg/L and 25.16 ìg/L are recorded in Montezuma and Lower Gallinas, respectively. Preliminary studies show highly proportional relationships between arsenic, stream flow, turbidity and TSS throughout different hydrological seasons (p- values <0.0001). Soils and rocks that constitute the watershed are being analyzed since they appear to be potential contributors of arsenic to the river.

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MAPPING GEOMORPHIC AND HYDROLOGIC FEATURES FROM DIGITAL TOPOGRAPHY FOR THE RIO SALADO WATERSHED

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Poster Abstract 14

Recent advances in digital terrain modeling and geographic information systems (GIS) have facilitated the analysis of geomorphic and hydrologic features within complex landscapes. Computer-based algorithms utilizing digital representation of topography may accurately extract landform features, including the delineation of major geological units and their internal variability. In this study we use two terrain analysis algorithms and digital elevation models (at 10-m and 30-m), coupled with field observations, to aid in feature extraction along the semi-arid Río Salado watershed in central New Mexico. We selected several regions where features, such as active channels, floodplains, valley bottoms, and dissected strath terraces, can be identified with field observations. Two GIS algorithms were utilized in the investigation for identifying valley bottoms (Gallant and Dowling, 2003) and delineating floodplains (Williams et al. 2000). Initial results for the basin demonstrate the algorithms correctly identify lower regions at various elevations, such as active channel deposits, as valley bottoms; while relatively flat, but higher, older terrace surfaces are mapped as ridge top features. Higher-order channels and fault-induced alluvial deposits are also correctly identified as valley bottoms. However, young, first order drainages are too small relative to the topographic resolution to accurately extract geomorphic features. Our results indicate that terrain algorithms can be used as a tool for improving the quality of mapped geomorphic, hydrologic, and soil-landscape features in semi-arid watersheds.

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HYDROGEOLOGIC CROSS SECTIONS OF THE ESTANCIA GROUNDWATER BASIN, CENTRAL NEW MEXICO

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Poster Abstract 15

Continuing investigations of hydrogeology, brackish-groundwater resources, and groundwater flow in the Estancia groundwater basin (EGWB) requires a detailed hydrostratigraphic and structural framework model. Nine new hydrogeologic cross-basin sections illustrate the major stratigraphic and tectonic elements of the EGWB between its northernmost edge (35° 12.5' N) and the south-basin area east of Mountainair. Sections terminate at the Estancia-Pecos (surface/subsurface) watershed divide. Base elevation is MSL, map scale is 1:100,000, and vertical exaggeration is 10x. Draft sections were also prepared at 1:1 scale to insure that structural interpretations are reasonable approximations of "spatial reality." Sections are in Adobe Illustrator® format, and subject to revision as more subsurface baseline information is acquired.

Primary information sources for this model update are 1) geologic and geophysical investigations of deep-subsurface conditions by Broadhead (1997, NMBM&MR Bull. 157) and Barrow and Keller (1994, GSA Spec. Paper 291), and 2) data initially compiled for N.M. Bureau of Geology [Mines] & Mineral Resources environmental-geology programs in the EGWB (Open-File Rpts. 245 and 258). Cross-section interpretations confirm Broadhead's (1997) observation that thin alluvial and lacustrine basin fill (<400 ft) conceal three interconnected, but distinct structural subbasins (Galisteo, West Estancia, and Perro). These are bounded by complex shear and dip-slip fault zones produced by late Paleozoic and Cenozoic compressional/extensional tectonism. Mechanisms for subbasin formation are still being debated (e.g., left vs. right shear; reviews in NMGS Guidebook 50); however, fracture and dissolution porosity-permeability associated with these deformation zones is clearly the major factor controlling groundwater flow and quality in bedrock-aquifer systems.

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SCHEDULING IRRIGATIONS ON TURFGRASS USING WEB-BASED CLIMATE DATA

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Poster Abstract 16

Recent droughts and increasing demands for limited water supplies in New Mexico and other southwestern states have caused many municipalities in the region to impose landscape watering restrictions. Potential negative effects of these restrictions on turfgrass quality, however, can be minimized if irrigations are scheduled to satisfy the minimum water requirement for acceptable turf quality. This requires accurate estimates of turfgrass maintenance evapotranspiration (ET) throughout the growing season. Crop coefficient (Kc) curves, derived from the ratio of measured turf ET to reference ET (calculated from weather data), were formulated for cool season and warm season turfgrasses at New Mexico State University's Agricultural Science Center at Farmington during a three-year (1998-2000) irrigation study. The seasonal Kc curves provided accurate turfgrass ET estimates for scheduling irrigations in subsequent years at the Farmington site when indexed against a cumulative growing degree-day time scale. When indexed against a relative growing degree-day timescale, the Kc curves might also provide accurate turf ET estimates for other sites in the southwest where accurate weather data are available. This paper summarizes the results from the Farmington study and proposes a methodology to efficiently schedule irrigations in turfgrass using web-based climate data.

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RESERVOIR BANK STORAGE AND THE SOLUTE BUDGET OF THE RIO GRANDE

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Poster Abstract 17

Past studies on water and chloride mass balance in Elephant Butte Reservoir have suggested that storage takes place in the banks of the reservoir. This implies that as the reservoir level rises some water from the reservoir is temporarily lost to bank storage. This phenomenon could have important implications for predicting the amount of water available in the reservoir as it recovers from record low levels experienced recently.

Using both water and chloride mass balance approaches is helpful in determining the sources and sinks of water in the system. For example, water loss due to evaporation results in increased concentration of chloride in the water in the reservoir, while water loss due to bank storage does not affect the chloride concentration in the reservoir. Therefore, using the chloride mass balance enables the effects of evaporation to be separated out from the water mass balance and allows for a better understanding of the movement of water in the system.

An integrated water and chloride balance model is being developed for Elephant Butte Reservoir using historical data. This model should be able to predict storage and chloride concentration in the reservoir given future climatic conditions and management practices.

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DETERMINATION OF SEASONAL FLOW LOSSES ALONG A REACH OF THE PECOS RIVER USING DATA FROM USGS GAGES

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Poster Abstract 18

The reach of the Pecos River between USGS gage near Lake Arthur and USGS gage near Lakewood (Kaiser Channel) was examined to evaluate seasonal losses of the river flows. An accurate estimation of the flow losses along this reach is critical for computing net depletions to Carlsbad water supply associated with modified Sumner Dam operations for the benefit of the Pecos bluntnose shiner and the effect of subsequent water offsets to those depletions. Loss estimates are equally important for estimating the effective flow into Brantley Lake from future augmentation pumping for the Pecos settlement. The purpose of this analysis was to determine the seasonal loss coefficients in this reach for different flows by using a simple method that utilized recent data (1980-2002) from USGS gages.

In this analysis USGS gage flow data were used from the following gages: near Lake Arthur, near Artesia and near Lakewood (Kaiser Channel). The data were first filtered to include selected periods of relatively steady flows at the three gages that meet the criteria listed below to reduce or eliminate the effects of gage errors, irrigation block releases and storm inflows on the gage readings:

1. Flows at Lake Arthur, Artesia and Kaiser Channel were less than 120 cfs.
2. The difference in the daily flow at the up-stream gage and the down-stream gage of the reach did not vary by more than 10 cfs in 3 days.
3. The length of the relatively steady flow period was at least 7 days.

The filtered steady flow periods were then grouped based on the four seasons of the year. Daily flows at the up-stream gage for these periods of consistent flow were compared to daily flows at the down-stream gage taking into consideration a 1-day lag time (i.e., today's flow at the down-stream gage was compared to yesterday's flow at the up-stream gage). The percent of flow lost between the two gages was determined for all instances observed. The average of those losses for each flow category are represented by the loss coefficients presented in this study. Flow-loss curves for the four seasons were developed from these average loss coefficients.

The method was used to assess the average flow loss for a given season of year and given flow. It was found that the loss coefficients determined in this study could represent low flow losses (< 40 cfs) in the reach more accurately than methods previously used.

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DIURNAL AND SEASONAL RESPONSES OF SHALLOW GROUNDWATER TO RIO GRANDE FLOW SOUTH OF SAN ACACIA, NEW MEXICO

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Poster Abstract 19

Riparian restoration efforts and interstate compact demands have motivated intense hydrologic characterization along a 50 mile stretch of the Rio Grande between San Acacia and Fort Craig, New Mexico. In collaboration with the New Mexico Interstate Stream Commission, the U.S. Army Corps of Engineers, and a S.S. Papadopulos and Associates, New Mexico Tech has established a groundwater-surface water monitoring network within this critical reach of the Rio Grande Valley.

Pressure transducers have been installed at 70 surface and groundwater monitoring points to provide a high-resolution picture of diurnal, seasonal, and event-dependent water losses/gains from the river to the shallow aquifer. Monitoring wells adjacent to the river show an almost immediate response to monsoonal-induced changes in river stage and the return to base flow conditions. During a September 2003 flood event, deeper wells showed a stronger pressure response than water table wells, temporarily reversing the downward vertical gradient. Diurnal groundwater fluctuations are pronounced from early spring until late fall. Daily fluctuations in July and August ranged from 5 to 95 mm/day, apparently controlled by evapotranspirative demand and site geology.

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DEVELOPMENT AND APPLICATION OF A SUB-REGIONAL GROUNDWATER MODEL FOR LONG RANGE WATER PLANNING, CASTLE ROCK, DENVER BASIN, COLORADO

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Poster Abstract 20

The purpose of this study was to predict behavior and productivity of the Denver Basin bedrock aquifers that provide supplies to Castle Rock (a major suburb to Denver, CO) over a 50-year planning horizon. One of the first steps in investigating future water management scenarios for Castle Rock involved development of a regional groundwater flow model to predict the decline in groundwater heads in each of the four aquifers of the Denver Basin. Water levels in the Arapahoe Aquifer have been steadily decreasing over the past twenty years, at an average rate of nearly 30 feet per year in the Denver South Metro area, adversely impacting water suppliers' ability to produce water from the bedrock-groundwater resource.

The regional model was prepared using MODFLOW2000 and was based on the SB-74 groundwater model, developed by the State Engineer Office using MODFLOW96 in 1998. For the Castle Rock study, we updated the SB-74 model with a significant amount of recent water level, well construction, and transmissivity data from the South Metro area. In addition to incorporating more recent data for detailed analysis of expected future water levels in the Castle Rock area, we have implemented two primary changes to the Denver Basin regional model:

- A telescopic mesh refinement, and
- Use of the multi-node well (MNW) module recently developed by the USGS for MODFLOW

The telescopic mesh refinement involved focusing the model grid on that portion of the Denver basin in the vicinity of Castle Rock, and significantly refining the model grid (both areally and vertically) in the subregion. The subregion, centered on the Castle Rock area, also includes adjacent areas so that model boundaries are located sufficiently far from the region of interest to minimize impact on model predictions. The boundary conditions for the subregional model have been obtained from the full-basin regional model results. The use of the MNW module allows for addressing inter-aquifer layering effect on well drawdown, as well as prediction of wellbore-radius heads via the built-in Trescott approximation capabilities of the module.

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APPLICATION OF PECOS RIVER DECISION SUPPORT SYSTEM FOR ANALYSIS OF ALTERNATIVES FOR RIVER OPERATIONS EVALUATED IN THE NEPA PROCESS

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Poster Abstract 21

A suite of hydrologic models referred to as the Pecos River Decision Support System (PRDSS) is being used as part of the National Environmental Policy Act (NEPA) process to evaluate proposed changes to river operations on the Pecos River to benefit the federally threatened Pecos bluntnose shiner, while conserving water supply to downstream users. Depletions to the river system caused by changes to river operations for Endangered Species Act (ESA) purposes, without proper offsets to those depletions to maintain a balance between supply and demand, could result in negative impacts to water users downstream and inhibit the State of New Mexico's ability to maintain compliance with the Pecos River Compact. The PRDSS is used to describe these depletions and offsets.

The New Mexico Interstate Stream Commission is jointly preparing an Environmental Impact Statement with the U.S. Bureau of Reclamation, evaluating the potential environmental impacts of the proposed changes in river operations at Sumner Dam and the implementation of a water acquisition program. All depletions generated from meeting flow targets defined in the final alternatives will be offset using a variety of water sources that may also provide water to directly benefit the fish. The ability to meet flow targets and offset resulting depletions will be evaluated using the PRDSS, a sophisticated system of groundwater and surface water models linked via respective inputs and outputs covering nearly the full length of the river system to the New Mexico-Texas state line. Model results will provide vital information to be used in the decision-making process.

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SOUTHERN ROSWELL BASIN GROUNDWATER QUALITY: COMPILATION AND SYNTHESIS OF HISTORICAL AND RECENT DATA

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Poster Abstract 22

This paper describes our current understanding of groundwater quality in the southern Roswell Basin based on historical and recently acquired data. The New Mexico Interstate Stream Commission is currently evaluating the development of a well field in the southern Roswell Basin to pump groundwater to supplement Pecos River flows as needed to augment CID water supplies and to ensure long-term compliance with the Pecos River Compact, consistent with conditions called for in the Carlsbad Project Settlement Agreement. As part of that evaluation, water quality (specifically sulfate salinity) has been identified as a potential issue of concern, in particular how augmentation pumping may impact the quality of irrigation water in the area, and in turn how that may affect agricultural soil productivity. This work focuses on evaluating groundwater quality in the vicinity of the study area with regard to issues related to the development of an augmentation well field, as well as developing a baseline understanding of soil quality in the area. We describe results from a compilation of historical water quality data for the region, as well as field data for water levels and groundwater quality from the Fall of 2003 through Summer 2004. In addition, soil samples were obtained from land irrigated by groundwater, as well as non-irrigated lands, and the samples were analyzed to determine the geochemical profile of the soil water. A synthesis of the data is presented, and preliminary conclusions related to anticipated future trends on groundwater quality in the area are described.

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FLOODPLAIN MAPPING IN NORTHWEST EL PASO, TEXAS

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Poster Abstract 23

Floodplain maps for seven arroyos in Northwest El Paso were developed using Geographic Information Systems (GIS) software and Hydrologic Engineering Centers River Analysis System (HEC- RAS). GIS software included ArcView GIS with Spatial Analyst, 3D Analyst and HEC-GeoRAS extensions. High resolution LIDAR elevation data were processed in ArcView and exported to HEC-RAS for processing with hydrologic data. HEC-RAS results were exported back to the GIS and used to delineate floodplain maps showing water depth and velocity. 3D visualization of the floodplains were developed using ArcView 3D Analyst. Results of the project were used to create FEMA maps for housing development areas.

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REMOVAL OF PERCHLORATE FROM DOMESTIC WATER SYSTEM

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Poster Abstract 24

Perchlorate contamination of groundwater is a significant emerging issue. There have been confirmed perchlorate releases in at least 20 states throughout USA. Perchlorate salts are used in the manufacture of solid rocket propellants, missiles, and fireworks, and in many other applications. Unfortunately, industrial waste handling and disposal practices have led to environmental contamination by perchlorate, which can persist for many decades in groundwater and surface water sources. Perchlorate is of concern because it can interfere with thyroid gland's ability to produce metabolic hormones, thus affecting normal growth and development. EPA has recommended listing of perchlorate as a potential hazardous compound in drinking water, promulgation of regulations, including establishment of a maximum contaminant level (MCL) less than 10 ppb in drinking water is expected soon. This has spurred many research efforts to mitigate the perchlorate contamination problem. Among many treatment technologies, adsorption of perchlorate on ion-exchange resins seems to be the most promising one.

Several different treatment methods including adsorption on ion-exchanged resins, sonication system and biological treatment were evaluated in this work. Simulated well water containing 2 ppm of perchlorate is treated using each technology and then analyzed for remaining perchlorate using a Dionex ion chromatograph. A complete breakthrough curve of perchlorate in water on Purolite® A-530E resin was measured after continuous feeding the 2 ppm water into the resin column for about two weeks. Mass transfer zone and adsorption capacity of the resin at the experimental conditions were determined from the breakthrough data. These data can be used for designing large scale water treatment system for perchlorate removal from domestic water system.

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BASE OF THE SANTA FE GROUP IN THE MESILLA AND SOUTHERN JORNADA BASINS

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Poster Abstract 25

This poster presents a map of the base (contact between bed-rock and basin-fill) of the Santa Fe Group deposits in the Mesilla Basin and southern Jornada del Muerto Basin. The map is one of the significant contributions made to the understanding of south-central New Mexico, far west Texas, and northern Chihuahua, Mexico hydrogeology by the recently published report entitled *Creation of a Digital Hydrogeologic Framework Model of the Mesilla Basin and Southern Jornada Del Muerto Basin*. The report is listed as New Mexico Water Resources Research Institute Technical Completion Report # 329. The authors are John W. Hawley and John F. Kennedy, with significant contributions made by the following NMSU students: Molly Johnson, Phil Dinterman, Jared Martin, Mike Cleary, Kyle Graff, Janelle Prude, Sean Carrasco, and Marquita Ortiz. This poster covers the general steps taken to build *the Base of the Santa Fe Group in the Mesilla and Southern Jornada Basins* map.

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GROUND- AND SATELLITE-BASED ASSESSMENT OF VEGETATION AND HYDROLOGIC CONDITIONS IN THE RIO GRANDE, PECOS, AND CANADIAN RIVER WATERSHEDS

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Poster Abstract 26

Due to the concern for improving the riparian environment and the need to save water where possible, salt cedar has been identified to be one of the invader species most desirable to eradicate. The large area of infestation of the plant lends itself to being mapped through a statewide remote sensing effort in order to better coordinate and prioritize eradication projects. Under funding authorized by the New Mexico legislature for salt cedar eradication and monitoring, New Mexico EPSCoR has begun a program to:

1. Provide accurate maps of riparian zones along the Rio Grande, Canadian, and Pecos River systems through the use of remote sensing, ground-validation, and geographic information system (GIS) capabilities.

2. Develop maps of salt cedar areas within the riparian zones of the three river systems using direct hyperspectral imagery and seasonal Landsat imagery.

3. Develop maps of evapotranspiration (ET) based on remote sensing and state-of-the-art models currently used by groups at the University of New Mexico, New Mexico Tech, and New Mexico State University.

4. Validate remotely sensed ET estimates for the river systems through the establishment of ET towers and associated instrumentation on sites in salt cedar areas on those rivers.

5. Develop standardized protocols for GIS use along with an information management system that has appropriate protocols, metadata and standards for managing the diverse array of information collected in salt cedar eradication monitoring (e.g., flux tower, groundwater, weather, vegetation, and wildlife data).

6. Continue long-term ET mapping as a monitoring activity to evaluate changing environmental conditions, riparian restoration efforts, and forest thinning.

This project was initiated in July 2004; we will report on our progress to date.

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EVAPOTRANSPIRATION OF PECAN IN THE MESILLA AND RINCON VALLEYS

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Poster Abstract 27

Pecan is one of the major crops grown in the Mesilla and Rincon Valleys. It covers about 25% of the irrigated acreage in the Doña Ana County but its water use is not well understood. A 75 ft tower was installed in June of 2001 in a pecan orchard (Rincon Orchard, R4) located at Stahmann Farms Incorporated (lat: 32-10-36.08 N, long: 106-44-22.39 W; elevation 1144 m) about 26 km (16 miles) south of Las Cruces. Evapotranspiration (ET) of pecan was measured using a one propeller eddy covariance system (OPEC) from June 2001 through December 2003. A three-dimensional eddy covariance system was also used as a check for OPEC system. Actual ET of pecan measured during 2003 was 58 inches.

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MEASURING SKIN TEMPERATURE OF WATER USING AN INFRARED THERMOCOUPLE

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Poster Abstract 28

Skin temperature of water bodies is used in estimating evaporation. Measuring skin temperature of water bodies such as ponds, rivers and lakes is a challenge. Several methods have been applied that involve thermocouple wires floating on the water bodies. These methods have some errors induced in the measurements due to submergence of the thermocouple or shading by the buoyant material. This study looks at an alternative method by using an infrared thermocouple to measure skin temperature. An experiment was set up outside the Civil and Geological Engineering Department at New Mexico State University, Las Cruces, New Mexico.

A precision infrared surface temperature transducer was compared to two standard thermocouples (model T108 by Campbell Scientific Inc.) and a copper-constantan thermocouple (TC1) in an experimental setup. The two sensor measurements by TC-108 and TC1 of skin temperature were highly correlated ($Y = 1.02 X + 0.22$; $R2 = 0.9904$, $n = 1324$; Y = TC-108 and X = TC1). A comparison between TC1 and an infrared thermocouple was also highly correlated with R2 of 0.9774 ($Y = 1.07 X - 1.71$, $n = 1324$; Y = Infrared and X = TC1). Results indicated that infrared thermocouple could be used to measure more accurately the skin temperature of water.

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