AUTOMATED CREST-STAGE GAGE APPLICATIONS IN NEW MEXICO

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Poster Abstract 1

The highly transient and often destructive nature of streamflow in ephemeral channels presents many challenges to the use of traditional streamflow-gaging techniques. These challenges have resulted in poor documentation of streamflow in these ephemeral channels. Most streamflow data for ephemeral channels have been collected at the crest-stage gage (CSG), which is the most common alternative to traditional streamflow-gaging techniques. The CSG provides a measure of peak stage for a given location and a given time period (the time between site visits).

An automated crest-stage gage (ACSG) was developed by installing a self-contained data-logging pressure transducer in the external framework (2-inch-diameter steel pipe) of the traditional CSG. In addition to the data-logging pressure transducer, the traditional cork and wooden lathe configuration was retained so that the peak stage of the pressure transducer can be cross-checked with the peak stage recorded by the cork line. The ACSG measures and records stage at a user-selected time interval, which provides a continuous record of stage and, thus, a more complete characterization of streamflow. Information provided by the ACSG includes the date and time of peak discharge, the number of streamflow events between site visits, and the duration of each streamflow event. This poster reviews the equipment and methods used and the data collected over the past year at a network of six ACSG's in the New Mexico District.

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ARSENIC REMOVAL FROM GROUNDWATER: SOL-GEL SYNTHESIS AND PROPERTIES OF MESOPROUS ACTIVATED ALUMINA ADSORBENTS

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Poster Abstract 2

Effective in 2006 the EPA will lower the drinking water standard for arsenic from its current 50 ppb level to 10ppb. It is estimated that as many as 20 million Americans consume water containing arsenic at health threatening levels. The impact this new standard has on rural New Mexico communities is staggering, which has spurred interest in the development of cost effective removal technologies.

Activated alumina has been studied extensively and is used in a number of remediation applications. It has been used for arsenic removal with mixed success. Low surface area alumina with non-uniform pore size distribution is widely available at a very low cost. This alumina has successfully removed arsenic from drinking water; however, this creates a large volume of waste which must then be disposed of. This significantly increases both the cost and the environmental impact. Presently, a sol-gel derived activated alumina with a high surface area and uniform pore size distribution is being characterized. Preliminary experiments show a surface area in excess of 350 m2/g. In batch experiments this alumina has demonstrated an adsorption capacity of 0.5 mg/g in equilibrium with a final arsenic (V) concentration of 300 ppb. This is significantly higher than values reported for other alumina adsorbents. Current experiments are focusing on obtaining breakthrough data, the effect of iron impregnation on arsenic removal, and competing ion phenomena. If effective, this alumina could drastically reduce the cost and environmental impacts associated with meeting the new EPA regulation.

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WATER-QUALITY CHARACTERISTICS OF THE MOUND SPRINGS COMPLEX, WHITE SANDS MISSILE RANGE, LINCOLN COUNTY, NEW MEXICO

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Poster Abstract 3

This poster presents selected water-quality characteristics of the flowing springs of the Mound Springs complex in the northern Tularosa Basin in White Sands Missile Range, Lincoln County, New Mexico. The springs and associated ponds are located in gypsum mounds above Quaternary alluvium on the floor of the Tularosa Basin. The Mound Springs complex is a group of seven flowing springs (North Mound, Main Mound, Meinzer Mound, West Mound, Dead Oryx Mound, Hare Mound, and South Mound Springs). The Main Mound Spring is one of the only four habitats of the White Sands pupfish (*Cyprinodon tularosa*) in the Tularosa Basin.

Though some of the flowing springs have more than one water analysis, only detailed water analyses for ponds at five flowing springs (North Mound, Main Mound (upper pond), West Mound, Dead Oryx Mound, and South Mound Springs) from one sampling event in 1996 are presented in this poster. The water in the seven springs is usually brackish. The dominant cations are calcium and sodium; the dominant anions are sulfate and chloride.

The preparation of two publications in cooperation with White Sands Missile Range is currently in progress. The New Mexico Bureau of Geology and Mineral Resources is working on a geologic report and geologic map at a scale of 1:24,000 of the Mound Springs complex and U.S. Geological Survey Mound Spring 7.5-minute quadrangle topographic map. The detailed hydrologic data, including streamflow, available from 1911 through September 2002 are being compiled for a USGS publication of springs and surface waters in the northern Tularosa Basin in White Sands Missile Range and Lost River/Malone Draw in Holloman Air Force Base.

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APPLICATION OF PRESSURE TRANSDUCER DATA FROM NESTED PIEZOMETERS TO DETERMINE VERTICAL SEEPAGE VELOCITIES WITHIN THE ALLUVIAL AQUIFER IN LOS ALAMOS CANYON

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Poster Abstract 4

A series of piezometer nests were installed at several locations in upper Los Alamos Canyon during March-May 2001. Pressure transducers (In-Situ MiniTROLL and MPTROLL 8000 probes) were installed in each piezometer and were used to measure differential water levels in each piezometer nest at 30-minute intervals during the period from July 2001 through September 2003. The purpose of this study was to investigate magnitudes and locations of groundwater seepage from the alluvial aquifer to underlying geologic strata, potentially providing a source of recharge to intermediate-depth perched aquifers and the regional aquifer. A QA program consisting of periodic (monthly to quarterly) checks of transducer data against manual water level measurements was implemented to insure a high level of confidence in the transducer data sets. The differential head data were used to define the magnitude and variability of vertical gradients at each piezometer nest location. Slug tests were also performed in each piezometer to determine varying hydraulic conductivity values for the alluvial sediments. These data were used to perform seepage velocity computations by applying Darcy's law in the vertical dimension. Mean computed seepage velocities were found to vary from 5.8 cm/day to 1.4 m/day at the evaluated locations. Varying upward gradients were observed during some periods at some sites resulting in upward seepage velocities of as much as 4.8 m/day. The highest seepage velocities were observed as short-lived events associated with the initiation of major streamflow recharge events. The greatest magnitude of downward seepage velocity was observed at the LAP-1.5 site, located near the projected trace of the Guaje Mountain fault zone, supporting the hypothesis of enhanced seepage losses from the alluvium into fractures associated with faulting.

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DIGITAL HYDROGEOLOGIC-FRAMEWORK MODEL OF BASIN-FILL AQUIFER SYSTEMS IN SOUTH-CENTRAL NEW MEXICO AND ADJACENT PARTS OF TRANS-PECOS TEXAS AND CHIHUAHUA

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Poster Abstract 5

This presentation summarizes progress in development of a new digital hydrogeologic-framework model of major basin-fill aquifer systems that collectively form the primary binational groundwater resource in the south-central New Mexico border region. The model covers a 20,000 km² (~7,700 mi²) area of the southern Rio Grande rift tectonic province that comprises the Mesilla Basin, bordering ranges, and adjacent parts of the Palomas, Jornada, and Hueco-Tularosa basins. It extends down the Rio Grande Valley from Caballo Reservoir to near Fabens in southeastern El Paso County, Texas, and includes the Las Cruces-El Paso-Ciudad Juárez Metro-district with a population of about 2 million. Research to date is part of a multi-institutional/disciplinary project, with the New Mexico Water Resources Research Institute coordinating hydrogeologic/GIS (Geographic Information Systems) activities during the past two decades. Three surficial hydrogeologic maps, two regional structure-contour maps on the base of Neogene Santa Fe Group basin fill, and 33 schematic cross sections have been completed. Emphasis is on development of conceptual models of hydrogeologic-geohydrologic-geochemical systems at sites of nested piezometers and hydrogeochemical research in the Mesilla Basin-Paso del Norte-western Hueco Bolson area. Digital GIS methodology (e.g., ARC/GIS® and Adobe Illustrator®) integrates hydrogeologic elements such as aquifer-system hydrostratigraphy and lithofacies assemblages, basin (bedrock) boundaries, and internal-basin structure. The "template" for our model is 3-dimensional and has a combined map-fence-diagram format (1:100,000 map-scale, 10x cross section vertical exaggeration, and a base elevation of msl to 300-m asl). For supporting documentation, see NM WRRI Technical Completion Report No. 332, with CD ROM (Hawley and Kennedy, 2004-2005) http://wrri.nmsu.edu/publish/.

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HYDROLOGIC AND WETLAND-HABITAT RESPONSE TO LATE QUATERNARY CLIMATIC CHANGE, NORTHERN TULAROSA BASIN, NEW MEXICO, DETERMINED BY SEDIMENTOLOGY AND GEOMORPHOLOGY

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Poster Abstract 6

Two hydrologic systems determine the landforms and sedimentary facies preserved in the northern Tularosa Basin: 1) the surface water runoff and clastic sediment delivery system of Carrizozo Creek, Salt Creek, and Three Rivers and their tributaries, and 2) the sulfate-laden groundwater system that dissolves Permian gypsum and reprecipitates it in extensive springs, marshes, and lakes. The relative dominance of Quaternary springs, wetland habitats, rivers, and lakes in the northern basin has undergone extensive spatial and temporal changes as indicated by both clastic and precipitated sedimentary deposits and landforms. The present-day gypsum buildups of Mound Springs complex occupy the western flank of an earlier and much larger accumulation of spring gypsum, covering an area of at least 16 km^2. Similar extensive spring deposits occur to the northeast and southwest of the Mound Springs area.

Lacustrine evaporite and siliciclastic sediments indicate that shallow saline lakes occupied the floor of the Tularosa basin below an elevation of ~3960 ft (1207 m) by at least ~35 kyrs B.P. (radiocarbon age). During the last glacial maximum (LGM) the lake experienced large influxes of siliciclastic sediment. LGM lake expansions represent times when fluvial and lacustrine systems and wetland habitats in contributing watersheds to the north (e.g., Salt Creek, Carrizozo Creek, and Three Rivers watersheds) were integrated and produced an extensive fluvio-deltaic complex along the northern margin of Pleistocene Lake Otero. Laterally extensive surface deposits of gypsum along the present-day Salt Creek drainage were deposited in a large, gypsum-precipitating wetland area covering at least 50 km^2. The gypsum deposits, up to 3 m thick, contain abundant fossil ostracodes and aquatic, pulmonate gastropods and apparently accumulated after desiccation of Lake Otero during a latest Pleistocene-early Holocene (Younger Dryas?) episode of comparatively wet climate. Extensive deflation, eolian sheets and dunes, erosion of arroyo channels in the piedmont aprons and along salt Creek modified the landscape in Holocene time. The snout of the Carrizozo lava flow, with a cosmogenic age of 5200 years (Dunbar 1999), covered earlier gypsic spring, marsh, and playa deposits.

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WATER QUALITY IMPROVEMENT ALONG THE SANTA FE RIVER

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Poster Abstract 7

Through a multi-phased, multi-partner effort, the State Land Office has implemented a rehabilitation project along a one mile stretch of the Santa Fe River on state trust lands using Clean Water Act §319 Funding, provided through the Environmental Protection Agency and New Mexico Environment Department. This project began in 1999 and will conclude this December 2005.

The Santa Fe River has its headwaters in the lower Sangre de Cristo Mountains. The upper part of the river is impounded with a series of dams for municipal use in the City of Santa Fe. Below these dams, much of the Santa Fe River's length, through the urbanized area of Santa Fe County, is an ephemeral reach with a non-functioning riparian system. The river runs through state trust land at the edge of the City limits. The river is negatively influenced by urbanization, gravel mining, storm water runoff, illegal solid waste disposal, off road vehicle use, and other disturbances. These impacts are categorized as Nonpoint source pollution that impairs water quality and the aesthetics of the river system through the community.

Challenges at this site include extensive bank erosion, channelization, and improperly constructed river crossings, solid waste accumulation and a general lack of riparian vegetation to stabilize the river and minimize bank erosion. To reduce erosion and sedimentation, numerous practices were installed that recreate proper functioning conditions in the riparian floodplain. Willow bundles and root-wad revetments were installed in two locations. Boulders were used to establish grade control structures and to increase meander length. Steep banks were angled back to a more stable slope, reseeded with native grasses and forbs, and mulched. Willow whips were planted extensively to stabilize the channel and recreate riparian wildlife habitat. A poorly-designed low water crossing was removed. Multi-seasonal work was essential to establish a stable meander pattern and decrease channel slope. Finally, hundreds of tons of trash, old tires and other debris were removed through several Land Office and community river clean-ups.

Methods and techniques used to evaluate the successes and obstacles of this project include stream channel profiles, aerial photographs, before and after photo documentation of site changes, as well as flow damage, vegetation techniques, piezometer/monitoring well data, and public education and outreach designed specifically to increase public participation and knowledge about the project.

Usually a dry river bed, this year the flow increased dramatically due to an increase in precipitation and releases by the City from the reservoirs. Recent flood events and increased impervious surfaces have made working in a modified system difficult to predict and model. Finding the right geometry for the river has taken several rounds of trial and error and may still be unable to withstand severe high intensity flooding. Ultimately, how well these modifications hold may be determined by the state of the river upstream, which will require a concerted effort from the community. The Land Office section of river will be managed in the future by Santa Fe County and the local neighborhood.

This project has achieved many of the goals originally proposed. By switching to softer, incremental management practices, as opposed to large-scale channel modifications, we were able to stabilize the river and control erosion thereby increasing water quality downstream in the perennial section. Through the combined efforts of large and small modifications, we have made substantial changes in the morphology of the floodplain; we have severely reduced the number of non-natives plant species in the riparian area and established vegetation throughout the project site increasing wildlife and a greater appreciation for the Santa Fe River.

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BASIN SCALE MODELS OF CLIMATE, HYDROLOGY, AND WATER MANAGEMENT: DECISION SUPPORT TOOLS FOR THE SAN JUAN BASIN

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Poster Abstract 8

The need for responsible water planning has been highlighted by the recent severe drought in southwestern North America, during which freshwater surface flows reached historical lows, and by concerns that such climatic extremes may be increasing in frequency and intensity due to global climate change. As part of the ZeroNet Water-Energy Initiative, the ZeroNet Decision Support System (DSS) provides a three-component computing environment: 1) Watershed Tools, based on the Watershed Analysis Risk Management Framework (WARMF), provide capabilities to model surface flows, both natural and controlled, under different climate and management scenarios; 2) the Quick Scenario Tool uses system dynamics modeling for rapid analysis and visualization for drought planning, economic analysis, and risk assessment; and 3) the Knowledge Base serves simultaneously as the "faithful scribe" to organize and archive data in easily accessible digital libraries, and as the "universal translator" to share diverse data. Using iterative modeling with the DSS, we developed the San Juan Basin Scenario Library to examine the hydrologic and economic influences of 1) extended drought (3-10 year duration), 2) increased temperatures (1-10° C increase), and 3) vegetation change (increased xeric vegetation and forest thinning). We generated model inputs for each scenario based on historical data for meteorology, managed flows, and land use. Simulations showed that drought, increased temperature, and vegetation changes impact water availability for all sectors (agriculture, energy, municipal, industry…), and lead to increased frequency of critical shortages. For example, if the recent drought continues, reservoir levels will drop below allowable levels after two years. In the face of growing concern over climate change, limited water resources, and competing demands, integrative DSS tools can enable better understanding of complex interconnected systems and enable better decisions.

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MULTIPLE PERMEABLE REACTIVE BARRIERS: BATCH DESORPTION FIVE YEARS LATER

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Poster Abstract 9

The affinities of radionuclides for various aggregates are relevant to the long-term evaluation of environmental remediation projects. Research on multibarrier technology at Los Alamos National Laboratory five years ago culminated in two sets of samples containing the mineral apatite, zeolite, Apatite II®, and Apatite II® treated with phosphorus. These aggregates have been in contact with Pu-239 and Am-241 solutions since that time.

The radionuclides now reside in three locations: the insides of the bottles, the solution, and the aggregates. To determine the distribution between these locations, we analyzed one set of the samples. Centrifuged solution analyzed by liquid scintillation counting (LSC) showed that only the Pu-239 zeolite sample had significant activity in solution. To determine the quantity sorbed to the bottles, they were filled with an acid solution and placed on a shaker for ~ 2 weeks. An Am-241 control was treated in the same manner. For most of the samples, 2 percent or less of the initial activity was recovered from the bottles. Leaching of the control bottle yielded a 43 percent recovery.

Most of the activity is therefore adhering to aggregates. Desorption of the aggregates is accomplished in a series of steps, each intended to decrease the pH of the solution. However, due to the buffering capacity of Apatite II®, this process has taken an extensive amount of time and is not yet complete. Percentages recovered in this manner varied from 0.02 percent to 3.98 percent. Total recoveries, normalized for the control results, vary from 0.34 to 10.97 percent, with untreated Apatite II® providing the least recovery in both groups. Am-241 samples yielded more, as a percentage, from both the aggregates and in total recoveries.

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HIGH-RESOLUTION GROUNDWATER MODELS FOR THE ASSESSMENT OF RIPARIAN RESTORATION OPTIONS AND RIVER CONVEYANCE EFFICIENCY

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Poster Abstract 10

A suite of groundwater models have been developed for the shallow riparian groundwater environment along the Rio Grande in New Mexico to support analysis of restoration options and river management strategies. Three fine-mesh, three-dimensional groundwater models were developed for the riparian area from Angostura to Belen spanning approximately 60 river miles. The model grid consists of cells of 250 feet x 125 feet with four model layers.

The three shallow riparian zone groundwater models (riparian models) represent physical processes relevant to assessing shallow groundwater conditions, exchanges between surface water and shallow groundwater within the floodplain of the Rio Grande, and interaction between shallow and deep groundwater systems. Using input from existing regional surface-water and groundwater models, the models developed in this study can be used to analyze transient interactions between flow conditions in the river (and riverside drains) and the shallow groundwater under various hydrologic conditions. Modeled interactions include seepage from the river, interception of shallow groundwater by drains, recharge to shallow groundwater from flooded overbank areas, and water depletions due to open water evaporation and riparian evapotranspiration. Riparian evapotranspiration rates are variable, depending on the existing mapped vegetation classifications in the riparian zone.

The riparian models improve our ability to assess shallow groundwater conditions important to water supply reliability in specific river reaches and to evaluate habitat restoration goals. The models have been used to evaluate the relationship of shallow riparian groundwater conditions to variations in (a) regional groundwater conditions, (b) flood magnitude and duration, (c) vegetation type and coverage and (d) alternate channel conditions. The riparian model simulations conducted illustrate the dynamic nature of riparian zone behavior, with inter-relationships among environmental components including groundwater, surface water and vegetation. These dynamics have implications for both water management and restoration activities.

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AMOUNT AND VARIABILITY IN TRIBUTARY INFLOWS TO THE RIO GRANDE

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Poster Abstract 11

Identifying and understanding the components that contribute to the quantity and quality of water within the Middle Río Grande Basin is an increasingly important task as the demand for this resource continues to escalate. As a result, additional emphasis is being placed on providing accurate supply projections and creating sustainable water plans in the region. This work assesses the role of tributary contributions to the Río Grande in the river reach from the Ottowi gauge to Elephant Butte using a geographical information system (GIS) and statistical analyses of historical stream gauge measurements. We specifically seek to quantify the amount and variability of tributary inflows to the Río Grande from several major watersheds. We find that significant tributary contributions arise from the Jemez River, Santa Fe River, Galisteo Creek, Río Puerco, and Río Salado. Focusing on these watersheds, we observe that the variability of inflows between tributaries can be attributed to differing seasonal responses (i.e., major precipitation forcing and subsequent runoff response), vegetation characteristics, and watershed areas. Statistical analyses show that the Jemez and Santa Fe Rivers exhibit peak flows as a result of snowmelt, while the Río Puerco and Río Salado experience peak flows as a result of summer monsoon events. Galisteo Creek exhibits a mixed response, and contributing factors are elucidated using GIS-based analysis of vegetation characteristics and rainfall data. This observational study provides insight that will enable an improved treatment of tributary inflows in simulation models of the Middle Río Grande.

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DEEP GROUNDWATER UPWELLING IN THE SOCORRO BASIN, NEW MEXICO: INFLUENCE ON WATER QUALITY AND MICROBIAL COMMUNITY STRUCTURE

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Poster Abstract 12

Chemical analyses of water samples from the Socorro basin of the Rio Grande rift suggest deep groundwater upwelling has a considerable influence on water quality and subsurface microbial community structure. The upwelling increases the salinity of the shallow groundwater, as previous researchers have noted. We hypothesize it also contributes arsenic, selenium, reduced iron and manganese, molecular hydrogen, and methane to the shallow groundwater. These constituents provide the potential for diverse microbial activity in the shallow alluvial aquifer.

Our primary study site is a well transect crossing the Rio Grande at San Acacia, the terminus of the Albuquerque Basin. The New Mexico Tech Rio Grande Project maintains the site and has identified it as a region of groundwater upwelling. We collected surface water samples from 2 locations and groundwater samples from 7 well nests, each containing a well completed at the water table and a well completed 25 feet below the water table. One nest also contained a deep well completed 75 feet below the water table. In addition, we collected baseline samples from two downstream transects having no evidence of groundwater upwelling.

The total dissolved solids content exceeds 6500 mg/L in some samples from the upwelling zone compared to 950 mg/L in the baseline samples. Iron, manganese, arsenic, and selenium levels are as high as 8 mg/L, 7.5 mg/L, 70 µg/L, and 200 µg/L, respectively, in the zone of upwelling compared to 1.6 mg/L, 1.3 mg/L, <40 µg/L, and <20 µg/L, respectively, in the baseline samples. Hydrogen and methane content is up to 42 nM and 320 nM, respectively, in the samples from the upwelling zone; analyses of the baseline samples are pending.

During sampling, we observed oxidized iron in water from wells completed at the water table and particulate sulfide in water from wells completed below the water table. These observations, along with the dissolved chemical analyses, suggest our molecular characterization of the microbial communities, which is presently underway, will reflect metal and sulfide oxidizing communities near the water table and sulfate reducing communities below.

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ECOHYDROLOGY OF ROOT ZONE WATER FLUXES AND SOIL DEVELOPMENT IN A SMALL DRAINAGE BASIN IN CENTRAL NEW MEXICO

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Poster Abstract 13

In semiarid complex terrain, landscape position creates niches for vegetation species through effects of aspect, slope and curvature on the redistribution of water, nutrients and variations in the soil energy balance. As a consequence, the ecology, hydrology and pedology of a semiarid basin are defined by the interaction of soils, plants and climate forcing occurring on a topographic surface. While these interactions have been studied for subtle terrain, little is known about the controls exerted by terrain position on ecosystem processes. This study describes numerical modeling experiments used to assess the effect of slope aspect on the root zone water fluxes and pedogenesis in a small drainage basin in the Sevilleta National Wildlife Refuge, New Mexico. In the study basin, opposing hillslopes are characterized by differences in plant composition and soil properties, with the north-facing hillslope dominated by one-seed juniper (Juniper monosperma) and the south-facing slope consisting of creosote bush (Larrea tridentata). Modeling results show differences in root zone water fluxes in the opposing ecosystems. Differences in the amplitude and frequency of soil moisture and soil water pressure correspond to changes in soil profile characteristics. It is believed that these variations in water fluxes reinforce the development of a calcium carbonate (CaCO3) horizon present at different depths. This suggests there is a feedback between plant establishment, soil water fluxes and geomorphic processes within the catchment.

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DESIGN AND IMPLEMENTATION OF A HYDROMETEOROLOGICAL FIELD CAMPAIGN IN THE VALLES CALDERA, NEW MEXICO

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Poster Abstract 14

In order to better understand land-surface interactions of semi-arid alpine regions, a spatially distributed soil moisture survey was held in the Valles Caldera during the North American Monsoon. The Valles Caldera provides a rare environment allowing the study of the alpine headwaters of the Jemez River, a major tributary to the Rio Grande; an unusual topography that may further elucidate the formation of convective cells in mountainous terrain; and a diverse set of ecosystems in a reasonably small area. The Jaramillo, Redondo, and La Jara watersheds were characterized in the process of this survey. The sites are organized into small transects going from wetlands near the streams to forested areas at a higher elevation to ensure that each ecosystem, aspect, and elevation was sufficiently represented. At each site, daily rainfall, meteorological variables, volumetric soil moisture, and soil temperature were measured. Daily volumetric soil samples were taken to confirm the other volumetric water content measurements. The data from the campaign will be supplemented by continued monthly monitoring of the sites.

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INFLUENCE OF LAND USE AND FOREST WILDFIRES ON WATERBORNE MICROORGANISMS, TURBIDITY & TOTAL SUSPENDED SOLIDS IN WATERSHEDS OF NORTHERN NEW MEXICO

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Poster Abstract 15

Microbial concentrations and loading, total suspended solids (TSS) and turbidity vary with stream hydrology and land use. This study, conducted for two seasons (2003-2004), utilized event activated auto-sampling sites and grab sampling to quantify and compare turbidity, TSS, and microbial (*E. coli*, *Enterococci spp*., *Cryptosporidium spp.* and *Giardia duodenalis*) concentrations, loads and yields from four watersheds in the upper Pecos river basin: a catastrophically burned montane forest, an unburnt montane forest, rangeland prairie and urban land use. The urban and prairie watersheds produced TSS, *E. coli*, *Enterococci spp*. and protozoan concentrations that were from 1 to 3 orders of magnitude greater than the montane watersheds. Loads and yields of TSS, *E. coli*, *Enterococci spp*. and protozoa were greatest from the urban watershed. Microbial concentrations were greater in the unburnt forested watershed than the burned watershed, possibly due to the proximity of animals and human habitation in the unburnt watershed. Turbidity is an effective indicator of TSS, *E. coli* and *Enterococci spp*., but not of protozoa. Event flow concentrations and loads for most water quality variables were greatest during storm events at each of the four sites. Automated event sampling shows that the greatest threat to public health from microbial contamination occurs during storm runoff events. Efforts to minimize and manage surface runoff and erosion would likely improve water quality in the upper Pecos drainage basin.

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PAIRED CATCHMENT STUDY FOR THE RÍO PUERCO FLOOD OF SEPTEMBER 2003

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Poster Abstract 16

The Río Puerco is an ephemeral tributary of the Río Grande spanning approximately 18,896 km^2 with mountainous forests to the north and semi-arid desert to the south. In mid-September 2003, a series of late monsoonal storms traversed the northern extent of watershed resulting in a flood pulse which propagated through the main reach of the catchment and into the Río Grande thereby substantially influencing streamflow as far south as Elephant Butte Reservoir. In order to better understand the hydrologic dynamics in the headwater regions of the catchment, we utilize a fully distributed model to simulate the flood within the Upper Río Puerco Watershed (1119 km^2). The Tin-Based Real-time Integrated Basin Simulator (tRIBS) prioritizes interactions between the vadose and saturated zone through the simulation of downward moving infiltration fronts and a variable groundwater surface. In order to model interconnections between the unsaturated and saturated zone, tRIBS requires accurate representation of soil, land use features, and topographic data. Following model calibration, we transfer the parameter set to the neighboring Torreon Wash Watershed (1344 km^2). Thus, this paired catchment study allows estimation of contributing flow from Torreon Wash and facilitates an understanding of rainfall-runoff relationships within an ungauged portion of the Río Puerco Watershed.

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QUANTIFYING NITROGEN SOURCES AND CYCLING ALONG THE UPPER RIO GRANDE

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Poster Abstract 17

Synoptic sampling of a 1200km reach of the Upper Rio Grande has been performed biannually since January 2000 to develop seasonal relationships between discharge, land use, and major water quality parameters. In general, water quality, both salinity and nutrient concentrations, degrades with distance downstream. Increased salinity is explained largely by evapoconcentration punctuated by localized inputs of saline groundwater. Both total dissolved nitrogen (TDN) and dissolved organic carbon (DOC) concentrations gradually increase with distance downstream; however for TDN, this trend is punctuated by large, localized inputs primarily from urban areas.

Increased spatial and temporal sampling of the Middle Rio Grande was conducted in June, July and August of 2004 to quantify the relationships between agricultural and urban land use and nutrient loading as well as identify potential nutrient sinks. Summer 2004 data indicate that urban wastewater is the largest and most consistent source of inorganic nitrogen to the river. In June and July TDN loads decreased in the river between Isleta and San Acacia, and the diversion of water through the adjacent agricultural drain system resulted in a net removal of nitrogen. However in August, TDN loads were higher in returning drains suggesting that agricultural systems had switched to a net source of nitrogen. Possible reasons for this change include high rainfall in August flushing accumulated solutes coupled with increased soil available nutrients at the end of the growing season.

Current research involves sampling shallow nested piezometers to determine how exchange with shallow alluvial groundwater impacts surface water nutrient loads.

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GROUNDWATER GRADIENT REVERSAL DURING FLOOD EVENTS ALONG A CRITICAL REACH OF THE RIO GRANDE

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Poster Abstract 18

By using a highly instrumented 50-mile reach of the Rio Grande, we are able to see how groundwater responds to changes in the river stage. This critical reach on the Rio Grande has 154 wells, 19 stream gages, and 70 pressure transducers that record hourly water levels, providing a detailed look at flood events. This high-resolution data shows a vertical gradient between the phreatic aquifer and the semi-confined aquifer that reverses during flood events. Gradient changes during flooding confirm the presence of a low permeability layer, at a depth varying between 20 and 50 feet, identified during well installation. A preliminary surface water/groundwater interaction model depicts the low conductivity stratum as a continuous layer. The detailed flood data is being used in a version of the numerical model to better explain the relationship between this semi-confining layer and the reversible vertical gradient.

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A GIS DATA MODEL AND TOOLSET FOR THE PREPARATION OF SPATIAL WATER BUDGETS

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Poster Abstract 19

A Hydrologic Information System toolset and data model designed to organize many common tasks encountered in the preparation of spatial water budgets is described. The data model brings together three components: (1) Spatial water consumptive use data derived from remotely sensed imagery; (2) water accounting units that are flexibly derived from land status, land cover, or proximity to local river axes or conveyance facilities; and (3) observed or modeled water quantities such as rainfall, runoff, river baseflow and depth to water. Raster and vector data at different scales and times are considered and are compatible with ARC Hydro data and the National Hydrography dataset. Related toolsets provide for data processing, aggregation and tabulation.

We have applied these techniques in New Mexico for regional data presentation and to generate input parameters for MODFLOW, RIVERWARE and spreadsheet based models.

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CHARACTERIZING THE HYDROLOGIC CONNECTIVITY BETWEEN THE RIO GRANDE AND SHALLOW RIPARIAN GROUNDWATER AT TWO SITES USING CONTINUOUS DEPTH TO WATER TABLE MEASUREMENTS AND SLUG TESTS

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Poster Abstract 20

Characterizing the hydrology of the shallow riparian groundwater of the Rio Grande Bosque is important for understanding the interactions with vegetation and the movement of nutrients and contaminants. Two research sites along the Albuquerque reach of the Bosque were established with a grid of 14 – 19 shallow groundwater monitoring wells. Well depths ranged from 200 – 300 cm and were spaced 30 to 40 meters apart. The distance from the wells to the river edge ranged from 3 meters to 90 meters. Each site has a pair or more pressure transducers measuring depth to groundwater every 30 minutes. The purpose of this study was to answer two questions: 1) how responsive is the shallow groundwater at these two sites to fluctuations in river discharge; and 2) how do shallow groundwater equipotential maps change throughout the year. Groundwater levels at both sites appear to respond to river discharge fluctuations between 13 and 18 hours during different seasons. Hydraulic conductivity measurements conducted at both sites using Hvorslev rising-head slug test method was compared to conductivity values calculated using ArcGIS. Water equipotential maps during different months were graphed and compared using ArcGIS spatial extensions. The hydrologic gradients at both sites were consistently around 1% but changed during heavy rain or snow melt.

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REVIEW OF GROUNDWATER HYDROLOGY ASSOCIATED WITH SPRING FLOWS AT BITTER LAKE NATIONAL WILDLIFE REFUGE (BLNWR), NEW MEXICO

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Poster Abstract 21

This review provides an overview of the groundwater hydrology at BLNWR along the Pecos River near Roswell, New Mexico. The primary focus was to evaluate the threat of groundwater depletion due to pumping on proposed critical habitat springs of three springsnails and one amphipod identified in a draft Endangered Species Act listing published in the 2002 Federal Register.

Resource indicators examined to assess BLNWR spring response to environmental stresses included groundwater levels, elevation of the critical habitat springs, and spring flows at BLNWR. Model runs using the OSE Roswell Basin Groundwater Model were used to separate effects of historical drought from groundwater pumping. A transient capture zone analysis was performed to examine areas of potential contamination threats to aquifers in the area. Future scenarios without and with the Lower Pecos Adjudication Settlement Agreement were considered to evaluate the impact of groundwater pumping on spring flows.

Principal findings include:
(1) Regional groundwater levels reached a minimum in the late 1970s and generally have been rising since.
(2) The historical record indicates that critical habitat spring source flows have not ceased flowing since at least 1940, even during historical droughts.
(3) Development immediately west of BLNWR may constitute a threat to spring water quality.
(4) State administration of groundwater, which increased after 1967 adjudication, will assure that future pumping will not exceed historical maximums.
(5) The Lower Pecos Adjudication Settlement and associated actions will provide significant conservation measures to protect the species from groundwater depletion.
(6) An extended drought exceeding historical conditions is the most likely threat to BLNWR proposed critical habitat's future water supply.

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COMPARISON OF METHODS ASSESSING GEOMORPHOLOGY IMPACTS ON THE LOWER PECOS RIVER

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Poster Abstract 22

As part of the Lower Pecos Adjudication Settlement and a related Miscellaneous Purpose Carlsbad Project contract, the state of New Mexico is planning on acquiring water rights from the Carlsbad Irrigation District (CID) and from farmland north of Avalon Dam. The State would then release from Avalon all or part of the acquired water rights to the Pecos River channel to help the State meet its Pecos River Compact delivery obligations (up to a maximum 50,000 acre-feet (af) each year). This report compares methods used to evaluate possible impacts to fluvial geomorphology of the river below Avalon Dam due to actions under the proposed contract.

The bimodal nature of flows in the Pecos River below Avalon Dam (generally the only time water is flowing below the dam is during a release) makes it difficult to apply traditional sediment transport calculations. Calculations that rely heavily on the flow frequency distribution (such as effective discharge rate or the Leopold and Maddox predictions of channel geometry) become skewed towards the very low flow rates. A calculation of the total sediment transport over a range of flows combined with historical aerial photo analysis and observations of both current and historical conditions proved the most useful for evaluating expected impacts.

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UNDERSTANDING THE HYDROGEOLOGICAL CHARACTERISTICS OF EL PASO LOWER VALLEY THROUGH GROUNDWATER MODELING

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Poster Abstract 23

Due to the severity of the drought experienced in the last five years in the Southwest, irrigation districts across the region have relied on increased groundwater pumping to supplement drought-induced surface water shortages. The field observations, coupled with modeling simulations using GFLOW 2000, analytical element method model for ground water flow, have allowed for the conclusion that water levels throughout the aquifer recover quickly due to factors such as high hydraulic conductivity in that part of the aquifer, seepage losses from canals and laterals, and agricultural irrigation. GFLOW 2000 also shows us that a hydraulic conductivity value of 45 ft/day in the modeling package settings accounts for a quick restoration of groundwater levels. Modeling results coupled with field observations account for groundwater. Results show that groundwater and surface water in the El Paso Lower Valley interact dynamically. As irrigation districts look for alternatives to better manage surface and groundwater resources, the essential interaction between surface and groundwater in the El Paso's Lower Valley should be well understood, and long term water pumping and possible canal lining alternatives to improve delivery efficiency have to be evaluated in the context of understanding surface water channels and the underlining aquifer as an integrated system. As such, actions that affect one function derive in the alteration of the other. Modeling results may serve water resources managers as a guide to design comprehensive alternatives to improve water resources use, conservation and conveyance efficiency.

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SPATIAL VARIATION OF GROUNDWATER AND SURFACE WATER IN THE EL PASO LOWER VALLEY, TEXAS UTILIZING GIS

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Poster Abstract 24

One of the basic challenges living in an arid region is to assure an adequate water supply for municipal, industrial, and agricultural uses. In the region, surface water has been used primarily for agricultural irrigation, while groundwater has been used for municipal and industrial purposes. In this study, both spatial characteristics of surface water and groundwater in the southern portion of the El Paso Lower Valley were evaluated using GIS to assure adequate supplement supply of groundwater for drought contingency. Farmers in El Paso County and Hudspeth counties rely on groundwater of the Hueco Bolson to supplement surface water shortage for agricultural irrigation in times of drought. Significant usage and reliance on groundwater is one of the many causes that have exacerbated the problem of declining water levels and water qualities in the Hueco Bolson. Preliminary results show the depth to groundwater varies from several feet to tens of feet. Groundwater in this region is in close communication with surface water, and it was observed that most wells near the river, canals, and laterals produced better quality water that those wells located farther from canals and laterals. The results also show agricultural pumpage in 2004 and 2005 is feasible for a short-term supplement to surface water shortage; however, water quality should be further analyzed and monitored to avoid possible damages to crops and soil due to high Sodium Absorption Ratios and probably high salinity.

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USING AN ENHANCED SUPERPOSITION MODEL FOR WATER RIGHTS ADMINISTRATION IN THE ROSWELL UNDERGROUND WATER BASIN

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Poster Abstract 25

S.S. Papadopulos & Associates, Inc. (SSP&A) prepared a superposition version of the recalibrated Roswell Artesian Basin Groundwater (RABGW) Model. The primary purpose of the superposition version of the RABGW model, which is known as the SKL model, is to provide a tool for evaluating the impacts associated with proposed changes in pumping patterns within the Roswell Underground Water Basin (RUWB). The SKL model was adopted by the Office of the State Engineer (OSE) for water rights administration in the RUWB in December 2004. Historically, the OSE has been using the Akin-Rao analytical model for water rights administration in the RUWB. The analytical model is based on sound hydrological and mathematical principles and has served well the administrative objectives. However, the analytical model has several limitations, including:

1. A one-dimensional groundwater flow system is assumed with simplified boundary conditions, and the groundwater flow system is solved as a one-dimensional flow system in the east-west direction.
2. All hydrogeologic boundaries of the aquifers and the Pecos River are idealized as vertical planes oriented in the north-south direction, and the model requires manual estimation of distances from pumping wells to hydrogeologic boundaries.
3. Only a single well can be associated with a single stress period.
4. The Pecos River is assumed to be in fully saturated hydraulic connection with the shallow aquifer.

OSE hydrologists have been working on the development of a numerical groundwater flow model for the RUWB for nearly a decade to overcome the limitations of the analytical model and to have a more realistic representation of the groundwater flow conditions in the RUWB. The numerical groundwater models of the RUWB, which permit explicit consideration of the detailed geometry of the river and the variations in the thickness and extent of the different aquifer units, are more complicated and, generally, more difficult to use than simpler models, such as the Akin-Rao Model. The superposition model provides a tool that is relatively simple to use, but incorporates more of the detailed information about the RUWB groundwater system than is included in the numerical models.

To simplify application of the superposition model, SSP&A developed a graphical user interface (GUI). The GUI manages three modeling components: pre-processing, running MODFLOW-2000, and post-processing. The GUI takes information about the changes in pumping patterns and locations where changes in groundwater levels are of interest and prepares the necessary input files for running the superposition model. The GUI can then be instructed to run the superposition model using the MODFLOW-2000 program. After the superposition model runs are complete, the GUI can be instructed to post-process the model results and to prepare various tables that summarize results in a form that is typically used in evaluating impacts from changes in pumping patterns.

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HYDRASLEEVE, A NEW PASSIVE, GROUND-WATER SAMPLER FOR ALL CONTAMINANTS

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Poster Abstract 26

Historically, the accepted protocol for sampling ground-water monitoring wells has required removal of 3-5 times the volume of standing water in the well screen, casing, and surrounding filter pack prior to sample collection. This "purging" was done to assure that samples came from the screened interval and did not contain stagnant water from the unscreened portion of the well. When using bailers or portable pumps, purging was a time-consuming, costly process. If the well was contaminated, purge water handling, containment, and disposal added expense and hazards to the sampling process. Sample quality and consistency were another issue. Turbidity, aeration, and degassing caused by rapid purging made this method suspect for many sensitive parameters.

Over the years, researchers interested in simplifying ground-water sampling have tried to find ways to reduce the burden and improve the sample quality associated with purging. Recent advances have included low-flow sampling and passive diffusion sampling. The underlying principal behind these methods and the new HydraSleeve sampler is the premise that the screened interval of the well is in dynamic equilibrium with the surrounding formation.

The HydraSleeve is a disposable, passive sampler that provides representative ground-water samples for all compounds without purging. It collects a "core" of water from a defined interval within the well screen with minimal disturbance and no mixing of the sample. The sampler is placed in the well prior to sampling and left in place until the well has returned to passive conditions. A single HydraSleeve can be used to obtain a sample from a specified vertical interval or several of the samplers can be stacked to provide a vertical contaminant profile within the well. A recent study completed at McClellan AFB, California compared samples collected using the HydraSleeve and five other passive samplers to low-flow and traditional purged samples. The report showed that, overall, the HydraSleeve provided equivalent or higher sample concentrations than low-flow or fixed volume purging at less than half the cost.

Kent Cordry has been active in the ground-water monitoring field for over 25 years. He is president of GeoInsight, a 15 year old company that focuses primarily on the development and production of direct-push equipment. He holds ten patents, including those covering the HydroPunch I, HydroPunch II, and HydraSleeve. In 1996, he received the NGWA's Technology Award for his contributions to the ground-water industry. Mr. Cordry spent 10 years as an environmental consultant, serving as project manager/senior hydrogeologist, managing site assessments throughout the United States. Prior to working as a consultant, Mr. Cordry served as a division manager for a Midwestern drilling company. He is a Certified Professional Geologist and Certified Drilling Contractor.

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MULTIVARIATE STATISTICAL ANALYSIS OF THE MEMBRES BASIN GROUNDWATER AQUIFER SYSTEM

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Poster Abstract 27

The border region is growing rapidly and experiencing a sharp decline both in water quality and availability, putting a strain on the quickly diminishing resource. Since water is used primarily for agricultural, domestic, commercial, livestock, mining and power generation, its rapid depletion is of major concern in the region. Tools such as Principal Component Analysis (PCA), Correspondence Analysis and Cluster Analysis have the potential to present new insight into this problem. The Membres Basin is analyzed here using the Multivariate Analysis methods. PCA is applied to geo-chemical data from the region, and a Cluster Analysis is applied to the results in order to group wells with similar characteristics. The derived Principal-Axes and well groups are presented as biplots and overlaid on a digital elevation map of the region providing a visualization of potential interactions and flow path between surface water and ground water. This also gives a better understanding of the chemistry and groundwater quality of the aquifer system.

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STAGE DISCHARGE RECORDER

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Poster Abstract 28

A device has been introduced in May of this year which was designed specifically to address water measurement needs as exist in New Mexico and further the goals of the State Water Plan by making Active Water Resource Management possible. The device, Stage Discharge Recorder (SDR), was developed specifically from requirements defined by the State Engineer of Colorado, several USBR water managers and several irrigation districts in November 2004. The prototype was delivered in April and was unanimously well received. Colorado, while different from New Mexico in many ways does share great similarities in hydrology and water rights law.

The design criteria for this device as defined by the agencies mentioned above and shared by many water users within New Mexico include:

- Measure stage
- Calculate discharge
- Totalize volume
- Create report that can be used in water rights proceedings
- Easy to set up
- Easy to operate
- Provide users access to all collected data
- Low cost

The SDR replaces hard to operate and maintain chart recorders that cost two to three times more.

Benefits to New Mexico water users include having the ability for the first time to collect stage records and have real time calculations of discharge and volume, compared to use of chart recorders where volume data may not be available until after the water year has ended.

Making this volume information available immediately, in an affordable package makes Active Water Resource Management possible.

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REMOVING URANIUM FROM WATER USING NATURAL NEW MEXICO SOILS

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Poster Abstract 29

In 1789, German chemist Martin Klaproth discovered uranium. Three naturally occurring radioactive U isotopes are: 234U, 235U, and 238U. Despite similar characteristics, the isotopes differ in radiological properties because of the varied amount of neutrons in the nuclei. Uranium is an alpha emitter; alpha particles are the least penetrating type of radiation. Therefore, they do not pose an external threat. However, when ingested or inhaled, the massive alpha particles cause damage internally. Epidemiological studies show that ingesting water with uranium levels as low as 14 μg/L (ppb) can lead to kidney damage. Depleted uranium (DU) is what remains when most of the highly radioactive isotopes of uranium are removed for use as nuclear fuel or nuclear weapons. DU is a very dense metal that is not malleable, and so its structure does not deform under extreme harsh conditions. At 600˚C, DU spontaneously combusts and spreads toxic uranium particles into the surrounding area. In nature, uranium is widespread, for example in soil, rocks and water. Uranium gets into drinking water when groundwater dissolves minerals that contain uranium. Some, but certainly not all parts of the world have significant amounts of naturally occurring uranium that elevate levels of uranium in the groundwater. In order to lower levels of uranium in drinking water, two common methods are implemented: reverse osmosis and ion exchange. Clays present an alternative and inexpensive method that uses the high cation exchange capacity (CEC) to sorb uranium and other heavy metals from water. Uranium abatement in water with clays occurs by two mechanisms: precipitation and sorption. Clays are a simple, inexpensive, and manageable form for disposal. Cleaner water can be simply decanted. Other toxic heavy metals should behave similarly (Pb is under investigation).

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