H21C-0337 0830h POSTER

Vernal pool hydroperiod: simulations of long-term dynamics

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Vernal pools are shallow, seasonal wetlands formed by the accumulation of seasonal rains on impermeable substrates. Vernal pools are part of a large set of ephemeral wetlands including prairie potholes, karst sinks, playa lakes, and savanna rain-pools. Research has shown the ecological importance of hydroperiod in the species richness of crustacean communities, the persistence and spatial distribution of amphibians, and plant community composition. Despite the well-known ecological importance of vernal pool hydroperiod, existing observational records are very short (typically < 5 years), unreplicated, and frequently lost in the informal gray literature. These issues suggest the need for a process-based model of vernal pool hydroperiod that can be applied to hind-cast historical patterns of hydroperiod variability based on meteorological records. This research developed a water balanced-based model for the simulation of vernal pool hydrology based on historical meteorological records for coastal vernal pools in Santa Barbara, California. Stochastic weather generation was also applied to evaluate the potential statistical distribution of vernal pool hydroperiod over long periods of time. The model suggests that hydroperiod is particularly sensitive to maximum pool depth, soil thickness, and soil water holding capacity. Results suggest that combinations of these factors can change flooding duration and return interval by more than 50% under identical weather conditions. These findings have significant implications for wetland restoration and management.

H21D MC: Hall D Tuesday 0830h

Environmental Transport Studies at Radionuclide-Contaminated Sites

Presiding: **J Tauxe,** Neptune and Company**; R Maxwell,** LLNL

H21D-0338 0830h POSTER

Use of Groundwater Chemistry to Evaluate Subsurface Flow at Yucca Mountain, Nevada

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Yucca Mountain, Nevada is a potential site for the disposal of high-level nuclear wastes. Groundwater at the site occurs in Tertiary volcanic tuffs and in Quaternary valley fill alluvium at lower elevations in the Amargosa Desert. Groundwater seeps downward to the water table through a thick unsaturated zone (UZ), then flows south and southeasterly from Yucca Mountain toward Fortymile Wash. The wash is a highly ephemeral watercourse that drains Fortymile Canyon and Jackass Flats southward. The wash crosses Highway 95 just west of Lathrop Wells, Nevada. Water table contours in Jackass Flats show that groundwater flow strongly converges on the axis of Fortymile Wash, indicating that the same structural conditions that cause topographic lows in the area also enhance the southerly flow of groundwater. Groundwater chemistry is being used to evaluate flow conditions at local and regional scales, and to help resolve technical issues concerning UZ and saturated zone (SZ) flow conditions and dilution processes. A number of perched zones have been found beneath Yucca Mt. in five different wells (Patterson et al., 1998). The major element chemistry of perched water is distinct from pore water chemistry in the UZ and more similar to the water chemistry of the SZ. The perched water is more dilute than the UZ pore waters, with generally lower chloride concentrations. The lower chloride concentration suggests that a fraction of the perched water is recharge that moves downward from the surface through fractures, and has less interaction with the host rock than pore waters. However, only 1 of 5 wells yielded perched water with bomb-pulse levels of tritium. Deuterium and O-18 stable isotope chemistry indicates that perched water has an intermediate composition when compared to SZ groundwater. It is isotopically heavier (less negative) than SZ water beneath Yucca Mountain, but lighter than groundwater from wells along Fortymile Wash where significant recharge occurs. The heaviest deuterium values occur in wells along Fortymile Wash (wells J-13, J-12, JF-3, and UE-29a#2) and are similar to present-day mean precipitation. The highest values occur in well UE-29a#2, where the water table has risen as much as 6 m (20 ft) in response to recharge from runoff events in Fortymile Canyon (Savard, 1998). Water chemistry also shows that significant flow occurs across a major fault zone, the Solitario Canyon Fault. Wells east of the fault have higher dissolved calcium and lower pH and dissolved sodium content than those immediately to the west. Wells SD-6 and H-3 are exceptions. These wells are east of the fault zone and close to it, and their water chemistry resembles that of wells west of the fault. This shows that a significant flux of groundwater crosses the Solitario Canyon Fault from west to east under the prevailing hydraulic gradients. Water table elevations west of the fault are as much as 45 m higher than those to the east, although head differences to the north vanish as the fault displacement lessens. Finally, at a regional scale, the chemical signature of water derived from Yucca Mountain and Jackass Flats can be traced at least 10 km (6 mi) S-SW of Lathrop Wells into the central Amargosa Desert.

H21D-0339 0830h POSTER

Modeling Sr-90 Retardation by Fractured Rocks Based on the Results of In Situ and Laboratory Research

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Industrial solutions from the surface storage of liquid radioactive wastes in Lake Karachay have been migrating in groundwaters for 50 years. Interaction of industrial solutions with fractured water-bearing rocks results in the formation of a plume body of contaminated rocks due to a partial retardation of the migrating radionuclides. In conducting research of the fractured rocks core samples from the wells located within the contaminated ground water plume, we have obtained empirical estimations of the retardation parameter (Sr-90 interphase distribution factor, Kd).

To interpret the experimental data on Sr-90 Kd, a method of modeling of strontium-90 retardation by fractured rocks has been developed. The process of transient filtration for a flow fragment from Lake Karachay was reconstructed. Epignose modeling of the industrial solution's main flow migrating from Lake Karachay in south direction was performed. By solving the inverse tasks Kd of strontium-90 was estimated for the fractured rocks.

H21D-0340 0830h POSTER

Research of Radionuclides Migrating in Porous Media Allowing for the "Solution-Rock" Interaction

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Industrial solutions from the surface storage of liquid radioactive waste in Lake Karachay, near the Mayak Production Association in Russia, enter groundwaters through the reservoir loamy bed and have formed a contaminated groundwater plume. In order to predict radionuclide migration with the groundwater flow in porous unconsolidated rocks and to assess the protective mechanism of the natural environment, it is necessary to allow for the solution-rock physical and chemical interaction described by the distribution factor (Kd).

In order to study radionuclide distribution in porous media, a numerical model was developed which models stontium-90 migration in a uniform unit of loams typical for the Karachay Lake bed. For the migration to be calculated, the results of the in situ and laboratory reasearch on strontium-90 sorption and desorption were used in the code, as well as strontium-90 dependance on sodium nitrate concentration in the solution.

The code uses various models of the solution-rock interaction, taking into account both sorption/desorption and diffusion processes. Numerical research of strontium-90 migration resulted in data on strontium-90 distribution in solid and liquid phases of the porous loam unit over different time periods. Various models of the solution-rock interaction affecting strontium-90 migration are demonstrated.

H21D-0341 0830h POSTER

Uranium Mobility in Sediments From the 300 Area of the Hanford Site

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The Hanford Site, located in South-Eastern Washington, was once home to cold war weapons grade plutonium production. Over the last ten years, the Site has shifted from production and operation to clean up and decontamination. One legacy still remaining at the Hanford Site is the 300 Area North Process Pond, which was used to treat industrial waste byproducts of the uranium fuel processing operation. More than ten thousand pounds of uranium have been recovered from the pond, yet contamination has still been found in the soils and groundwater beneath and around the Pond. The principle risk of this contamination is to groundwater in the 300 Area, where contaminant plumes are known to exceed applicable maximum contaminant levels. Previous studies report highly variable leach rates that appear to be a function of site-specific conditions and parameters. These parameters include: soil grain size and distribution, soil pH, EC, moisture content, organic matter, as well as mineralogical composition. A site-specific laboratory study was performed to determine uranium leach rates and adsorption-desorption partition coefficients for various sediments collected in and around the North Process Pond. Column tests involving saturated flow yielded sediment/sample specific U leach rates. Uranium concentrations in solution varied by as much as three orders of magnitude between sediment samples. Additional sediment characterization studies, including semi-selective extractions and x-ray absorption spectroscopy of size separates, are being conducted to determine if uranium solid-phase speciation can be measured/inferred and responsible for leach rate differences. These data and the site-specific leachates will be used to perform batch and column adsorption-desorption experiments, ultimately enabling us to predict partition coefficients/retardation factors for U under various future conditions and land use options.

H21D-0342 0830h POSTER

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In this presentation, we provide analytical solutions for the reactive transport of N-member radionuclide chains through a discrete fracture in a porous rock matrix using a system decomposition approach. Diffusion between the fracture and rock matrix has a large impact on the migration of radionuclides in matrix-fracture systems. We consider the transport of N-member radionuclide chains in a single-fracture-matrix system as a starting point to modeling more realistic and complex systems. Our results show that a daughter species may penetrate farther along the fracture than its parent species when a constant concentration boundary condition is applied and all species keep the same transport speed in the fracture if a pulse of the first species is released into the fracture. This solution provides a way to validate mathematical models of radionuclide transport in fractured rock, such as are being used to assess the performance of a potential nuclear-waste repository at Yucca Mountain.

This work was performed under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

H21D-0343 0830h POSTER

Resolution of the Hydraulic Connection Between the Volcanic/Alluvial Aquifer and the Paleozoic Aquifer at Yucca Mountain Using Temperature and Hydraulic Head Data

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Yucca Mountain, Nevada is the location of the proposed geologic repository for high-level nuclear waste in the United States. If radionuclides are released from the repository, they are expected to flow vertically through the vadose zone then laterally through the saturated zone. Flow in the saturated zone is generally to the south from Yucca Mountain toward Amargosa Valley. The performance of the repository will be evaluated in terms of radionuclide dose predicted at a distance of 18 km from the proposed repository. The predicted dose rates are sensitive to groundwater travel times and flux rates.

The saturated zone to the south of Yucca Mountain is complex, but for regulatory purposes it can be simplified to consist of three major units: (1) an overlying volcanic aquifer near Yucca Mountain that is believed to transition to an alluvial aquifer to the south near Amargosa Valley; (2) underlain by a thick series of low permeable volcanic units; and (3) the underlying regional Paleozoic aquifer. The intervening volcanic layer is thought to be sufficiently thick and of sufficient low permeability near Yucca Mountain to effectively prohibit any significant hydraulic communication between the upper volcanic/alluvial and the lower Paleozoic aquifers. However, there is insufficient geologic evidence to the south, closer to Amargosa Valley, to confirm whether the intervening layer continues to prohibit or restrict inter-aquifer flow. In particular, there is neither sufficient hydraulic conductivity information for the confining unit separating the aquifers, nor hydraulic head data from the underlying Paleozoic aquifer to resolve the nature of this hydraulic connection. Given that the Paleozoic aquifer has approximately 40 times the flux of the volcanic/alluvial aquifer, even modest upward groundwater flow from the Paleozoic aquifer could significantly alter either the direction or rate of flow in the volcanic/alluvial aquifer. Use of both hydraulic head and temperature data reduce the uncertainty in the hydraulic connection between the two aquifers. In conjunction with standard calibration, the system of equations that couple heat and mass transfer are inverted using Full-Bayesian techniques (Woodbury and Rubin, WRR 36(1), 2000).

ACKNOWLEDGMENTS This work was performed at the CNWRA on behalf of the NRC office of Nuclear Material Safety and Safeguards, Division of Waste Management under contract No. NRC-02-97-009. This paper does not necessarily reflect the views or regulatory position of the NRC.

H21D-0344 0830h POSTER

The Experience at Russian Nuclear Sites of Modeling Groundwater Flow on Different Scales

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The experience of developing models of different scales to predict contaminant plume migration in ground waters is analyzed. The method of developing a three-dimensional transient model is demonstrated to estimate high-density solutions migrating from the surface storage of liquid radioactive waste, using a two-dimensional regional model for setting boundary conditions (Lake Karachay, PA Mayak, Russia). The model is used to calculate three-dimensional transient distribution of pressure, density and concentrations of the dissolved admixtures in the non-confined aquifers. Interpolation is also specified to calculate boundary conditions parameters of the inserted models.

The method of constructing a local filtration model is described to predict the contaminant plume spreading from the operating ground of deep burial of liquid radioactive wastes (The Siberian Chemical Plant, Seversk). The local model uses smaller grid gaps over time and space and a more detailed stratiographic division of the section as compared to the regional model intended to be used for estimating groundwater resourses. The flow distribution within the local model boundaries is described as the products of an average annual flow and periodical time function (function of monthly fluctuations) and the function of spatial variables. The parameters of the distribution function, represented on the local model grid by the values, were determined by solving the inverse problem. The sensivity analysis of the target function of the inverse problem to the small variations of the average annual flows is described.

H21E MC: 124 Tuesday 0830h

Catchment Water Quality Modeling II *(joint with B)*

Presiding: **T Meixner,** Env. Sciences - UC-Riverside**; K Eshleman,** University of Maryland Center for Environmental Science - Appalachian Laboratory

H21E-01 0830h

Estimating Nutrient Loads to New York City Water Supply Reservoirs

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The Generalized Watershed Loading Functions (GWLF) model has been used to estimate streamflow, sediment and nutrient loads to New York City drinking water supply reservoirs. Several model revisions and calibration of critical parameters were required to adequately improve model performance. The revised GWLF model has been tested against watershed loads obtained through water quality sampling during storm and inter-storm periods. Based on the framework of the revised model, a strategy to evaluate watershed management activities has been developed. The strategy utilizes a combination of both literature based and field experiment measures of the effectiveness of best management practices (BMPs) along with a watershed wide accounting of BMP implementation. Advantages and disadvantages of this evaluation strategy are discussed including the use of empirical model algorithms, the reliance on studies from other watersheds and data needs versus availability.

H21E-02 0845h

Water Quality Modeling of an Urbanizing Catchment: Model Compatibility and Comparison

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Predicted pollutant loads and discharge for a variety of storms from the highly parameterized HSPF watershed model were compared with the same from a storm sewer based model. WinHSPF, is the latest USEPA effort to simulate point and nonpoint sources with land uses, while the Storm Water Management Model (SWMM) has also seen feature and process upgrades from public and private users. Although WinHSPF is highly parameterized, it lacks some features of urban catchments, such as storm sewer networks, that are present in the SWMM simulations. The different nature of these models and of their water quality segments might justify their combined use in mixed-use watersheds with both overland and storm sewer flow paths. SWMM can use build-up/wash-off or Event Mean Concentration (EMC) loading processes, while WinHSPF is also able to use a suite of nutrient routines accounting for pollutant generation. This paper discusses the advantages and disadvantages of integrating the models and possibly calibrating WinHSPF overland flow and loading processes with SWMM simulation output.

H21E-03 0900h

Calibration, Validation, and Spatial Sensitivity Analysis for the Distributed Watershed Model, SWAT2000, for Hydrology and Sediment Transport in a Northeastern Climate

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The Cannonsville Reservoir, which serves as a source of drinking water to New York City, has been under a 'phosphorous-loading restriction' due to the high phosphorus concentrations within the water body. These high concentrations are attributed to the nonpoint source loads from the agricultural land in the basin. Currently, the county is attempting the implementation of Best Management Practices (BMPs) in certain areas to abate this pollution problem. However, the county and regulatory agencies need a way to evaluate the effectiveness of the BMPs. In addition, it would be useful to have tool to project future conditions of the reservoir resulting from changing land use practices and BMPs.

A distributed watershed model, the Soil and Water Assessment Tool (SWAT Version 2000) was calibrated and validated for the Cannonsville Reservoir watershed. The calibration exercise was implemented on varying spatial and temporal scales and focused on hydrology and sediment, both transport mechanisms for phosphorus. The calibration results showed monthly correlation coefficients for hydrology above 0.7 for all of the four gage stations analyzed. Sediment loading results came within 1% of the long-term observed monthly average for the main calibration station (drains 85% of watershed) and within 1% for a smaller, upstream station. The model was validated by simulating an independent time period, while keeping all parameters set at values determined during the calibration exercise. The results of the validation showed similar correlations as the calibration (0.80 at main station and within 31% of observed average monthly sediment loads). Important model parameters adjusted during the calibration in order to model this Northeastern environment are discussed. These changes include efforts to accurately represent fragipan soils and snowmelt events. Limitations of the model and possible explanation for model-to-data differences are also presented. Primary limitations found in this study and supported by previous work included the model's simulation of snowmelt and snowmelt erosion.

Of additional concern is the sensitivity of the model to the uncertain model parameters. A sensitivity analysis was performed to investigate the impact of parameter changes on model output. Particular attention was given to the distributed nature of the parameters, especially those related to land use and soil type. Spatial distribution of the parameter changes is considered when analyzing such results as sediment erosion and final sediment loading to the reservoir.

H21E-04 0915h INVITED

Joint Application of Watershed Modeling Tools to Support the Management of Nutrient Loading to Chesapeake Bay

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Two watershed modeling tools are currently being applied in the Chesapeake Bay watershed to support the management of nutrient loading to tidal waters. SPAtially Referenced Regressions On Watershed attributes (SPARROW) models were developed by the United States Geological Survey to relate sources of nutrients (total nitrogen and total phosphorus) to stream loads throughout the 164,000 km^2 watershed. In a separate effort, the Chesapeake Bay Program has developed a watershed model using the Hydrologic Simulation Program FORTRAN (HSPF) modeling framework. These two modeling approaches are quite different in structure. The SPARROW models are statistically based and are spatially explicit. In contrast, the