

over 1.5 million people and supporting unique habitats for endangered species. The aquifer consists of limestone with some dolostone members of the Edwards Group that dip in a southeasterly direction. The up-dip freshwater zone of the aquifer is recharged with fresh water along the northern area of the outcropping Edwards Group. Adjacent to the freshwater zone is the saline-water zone that forms an interface at the down-dip limit of the fresh water. Though the freshwater/saline-water interface is spatially defined within the aquifer, little is known about the nature of groundwater flow between and along its surface. Structural, lithologic and hydrologic features may influence the possible up-dip migration of the saline water into the freshwater zone and may adversely affect current freshwater supplies. Freshwater/saline-water monitoring well transects were sampled for dissolved gas using both conventional and un-conventional methods to establish vertical profiles across the aquifer. Data revealed two highly distinct gas compositions between the zones. The upper freshwater zone is characterized by normal, atmospherically saturated water gas concentrations with slight enrichments due to excess air (^4He 60 $\mu\text{cc}/\text{kg}$). The lower saline zone displayed a very different gas composition, highlighted by extremely high concentrations of radiogenic ^4He (>20,000 $\mu\text{cc}/\text{kg}$) and minor amounts of excess ^{40}Ar contained in a gas composition rich in CO_2 , H_2S and other hydrocarbons. Vertical profiles of dissolved gas compositions across the interface show active flowing water along the interface, and sluggish, stagnant flow within the saline zone. These sharply contrasting zones are strongly influenced by the faulting in the aquifer and by the hydrostatic head within the freshwater zone. Both the faulting and the hydrostatic head in the freshwater zone of the aquifer appear to exert a major influence on the regional groundwater flow patterns.

H72D MCC: Hall C Sunday 1330h

Elucidating the Fate of Emerging Contaminants in Groundwater and Surface-Water Systems Posters (joint with B)

Presiding: J Landmeyer, U.S.

Geological Survey; P Bradley, U.S.

Geological Survey

H72D-0876 1330h INVITED POSTER

Emerging Water Contaminants: Technical, Legal and Policy Challenges

Rula A Deeb¹ (1-510-735-3005; rdeeb@pirnie.com)

Neven Kresic² (1-703-518-4181; nkresic@pirnie.com)

Maryline C Laugier¹ (1-510-735-3034; mlaugier@pirnie.com)

Michael C Kavanaugh¹ (1-510-735-3010; mkavanaugh@pirnie.com)

¹Malcolm Pirnie, Inc., 2000 Powell Street, Suite 1180, Emeryville, CA 94608, United States

²Malcolm Pirnie, Inc., 1101 Wilson Blvd., Suite 1400, Arlington, VA 22209, United States

Approximately 120 new chemicals are created each year due to ever-improving industry and technology markets. Releases of new contaminants into the environment can occur during production, use and disposal of these chemicals thereby leading to potential contamination of water supply sources. Very few emerging contaminants are regulated. In addition, knowledge gaps regarding emerging contaminants include lack health effects, occurrence (either because these compounds are not measured or because concentrations are below detection limits of readily available analytical techniques) and fate and transport in the environment especially with regards to mobility and persistence. The sources of these compounds are numerous. One source is treated wastewater, which is re-injected into groundwater aquifers for indirect potable reuse purposes. Emerging compounds of concern can be classified in various classes. This presentation will focus on contaminants, which have emerged in the last 10 years including pharmaceuticals (antibiotics/drugs), personal care products (polycyclic musks), pesticides/herbicides, industrial solvents (1,4-dioxane), gasoline additives (MTBE), disinfection byproducts such as NDMA (N-nitrosodimethylamine), and inorganic compounds such as perchlorate and arsenic. This presentation will present technical, legal and legislative challenges posed by the presence of these contaminants in water. Background information including chemicals history of use, sources in the environments, nationwide occurrence, physical and chemical properties, behavior in the environment and technologies for removal from soil and water will be presented.

In addition, case studies on MTBE, pharmaceuticals and personal care products, 1,4-dioxane, arsenic and NDMA will be discussed.

H72D-0877 1330h POSTER

Attenuation of Selected Emerging Contaminants During River Transport

Martin Reinhard¹ (650 723 0308; reinhard@stanford.edu)

Birgit Gross¹ (650 723 0315; grossb@stanford.edu)

Anneke Haderl¹ (650 723 0315; ahaderl@stanford.edu)

¹Stanford University, Terman Engineering Center, Stanford, CA 94305, United States

The ubiquitous occurrence of emerging (non-regulated) contaminants in the aquatic environment is of concern because some of these chemicals are biologically active at low concentrations and a potential threat to wildlife and human health. Emerging contaminants include a diverse range of chemicals, including pharmaceuticals, natural and synthetic hormones and industrial surfactants, such as alkylphenol ethoxylates (APEO) and their metabolites. To address the ecotoxicological impact of these chemicals, it is necessary to know their sources, removal efficiencies during wastewater treatment, and their behavior in the environment.

In this study, the fate of selected emerging contaminants in the Santa Ana River (SAR) in Southern California was investigated. The SAR originates in the San Bernardino Mountains and flows 80 miles into the Pacific Ocean. The SAR flow stems mainly from storm runoff, wastewater treatment effluents and several other minor sources. During the dry season, SAR flow is dominated by effluent from public wastewater treatment plants. Input into the SAR was studied by analyzing samples from four major treatment plants that employ different tertiary treatment processes. To assess the fate during river water transport and during wetland treatment, samples from six sites along the river were analyzed.

Effluent samples were analyzed every two months, river water every four months. River samples were taken considering the flow velocity, which is approximately 1 mile per hour. The analytical method involves solid-phase extraction using C-18 cartridges and extraction of three fractions. Samples were analyzed with and without further derivatization using GC/MS and GC/MS/MS.

Results indicate significant contaminant removal during river transport, presumably by photochemical oxidation. Within a distance of nine miles, pharmaceuticals, plasticizers, flame retardants, APEOs and metabolites were attenuated with removal rates ranging from 76% for a flame retardant to up to 97% for some APEO metabolites. The two pharmaceuticals gemfibrozil and ibuprofen were attenuated by more than 90%. Whether photochemical transformations are mainly responsible for the observed removals remains to be investigated.

H72D-0878 1330h POSTER

Empirical Models of NAPL Dissolution and Their Applications in Subsurface Contaminant Transport Modeling

Jonathan F. Sykes¹ (519-888-4567 ext 3776; sykesj@uwaterloo.ca)

Jianting Zhu² (979-458-4651; jzhu@cora.tamu.edu)

¹Department of Civil Engineering, University of Waterloo, Waterloo, ON N2L 3G1, Canada

²Department of Biological and Agricultural Engineering, Texas AM University, College Station, TX 77843-2117, United States

Three simple empirical models of nonaqueous phase liquid (NAPL) dissolution are proposed based on the NAPL mass conservation and the assumption of proportionality between the solute concentration and the remaining residual NAPL mass. The purpose of the proposed models is to predict the solute concentration in the vicinity of the residual NAPL as a result of dissolution. The predicted solute concentration decrease is used to simulate and account for the decrease of dissolution rate with time. The empirical parameters used in the proposed models that were obtained from one-dimensional simulations of water-saturated column are found to be also representative of variably saturated systems with a fairly reasonable success. It is found that the proposed models are fairly good for quantification of non-equilibrium dissolution, which is characterized by tailing of breakthrough curves. The models are especially useful for the situations of small residual NAPL saturation, which are typical for field applications.

H72D-0879 1330h POSTER

Compound-Specific Carbon and Hydrogen Isotope Analysis - Field Evidence of MTBE Bioremediation

Tomasz Kuder¹ (1-405-325-4453; tkuder@ou.edu);

Ravi V. Kolhatkar² (KOLHATRV@bp.com); Paul Philp¹ (pphilp@ou.edu); John T. Wilson³

(wilson.johnt@epa.gov); James E. Landmeyer⁴ (jlandmey@usgs.gov); Jon Allen¹ (jallen@ou.edu)

¹Oklahoma University, School of Geology and Geophysics 100 E. Boyd st., SEC 810, Norman, OK 73019, United States

²BP Amoco, Group Environmental Management Company (GEM) 150 West Warrenville Road, M/C H-7, Naperville, IL 60563, United States

³US EPA, Office of Research and Development National Risk Management Research Lab Subsurface Protection and Remediation Division P.O. Box 1198, Ada, OK 74820, United States

⁴U.S. Geological Survey, 720 Gracern Road, Suite 129, Columbia, SC 29210, United States

Compound-specific stable isotope analysis allows opportunity to determine the isotopic ratios of individual contaminants. The technique has been applied to confirm biodegradation in studies of chlorinated solvents and recently BTEX, MTBE and TBA. Chemical reactions (including bio- and inorganic degradation) tend to favor molecules with the lighter isotopic species (e.g., ^{12}C , ^1H), resulting with enrichment of the unreacted substrate in the heavier isotopic species (^{13}C , D), referred to as kinetic isotopic fractionation, so that the extent of fractionation may be used as a proxy for biodegradation. Processes such as volatilization, sorption etc., result in minimal degree of fractionation and do not interfere with the isotopic signal due to biodegradation.

The results presented here show the first successful applications of compound-specific isotope analysis to understanding MTBE biodegradation in the field, at both aerobic and anaerobic sites. Observed fractionations suggest that two different biodegradation pathways may be involved. At a number of anaerobic locations major fractionation effects were observed for both C and H; enrichment factors for both elements were approaching or exceeding -10. A laboratory microcosm study using an enrichment culture yielded similar results (C data only). A characteristic feature of these sites was the presence of high concentrations of TBA.

Conversely, at a number of sites, the C composition remained stable with little fractionation and stayed within the analytical precision range or changed minimally, while H displayed significant fractionation in excess of 60 per mil. Moderate agreement of the data with Rayleigh fractionation model was observed, suggesting that biodegradation effect was distorted by variability at the source or the plume was not homogeneous. The enrichment factor calculated for these data is similar to the one published for aerobic microcosm of MTBE-degrading culture from Vandenberg AFB by Gray et al. (Env. Sci. Tech., 2002, 36, 1931-1938) and appears to be in excess of -60 for H and under -2 for C.

The high H fractionation observed under aerobic conditions may be attributed to the initial, monooxygenase transformation of MTBE (cf., Deeb et al., Biodegradation, 2000, 11, 171-186). The anaerobic enzymatic reactions were not characterized yet, but a hydrolytic process may be responsible. Interestingly, isotopic fractionation at an anaerobic site, which was treated by oxygen injection, did not show differences between aerobic and anaerobic parts of the plume. Despite oxygen addition, there was no evidence for monooxygenase activity.

H72D-0880 1330h POSTER

Factors Affecting the Success of Enhanced Aerobic Biodegradation of MTBE and BTEX

James E Landmeyer¹ (1-803-750-6128; jlandmey@usgs.gov)

Paul M Bradley¹ (1-803-750-6125; pbradley@usgs.gov)

¹U.S. Geological Survey, 720 Gracern Road - Suite 129, Columbia, SC 29210, United States

At a gasoline-release site in South Carolina, a proprietary form of MgO_2 injected into the subsurface in a former underground storage tank (UST) area to increase dissolved oxygen (DO) levels did not elevate low (0 mg/L) DO levels nor decrease concentrations of benzene, toluene, or methyl tert-butyl ether (MTBE). In contrast, MgO_2 injected less than 200 meters downgradient rapidly increased DO, and benzene, toluene, and MTBE concentrations decreased up to 87%. These different results following oxygen addition to an anoxic fuel-contaminated aquifer can be related to differences in ambient hydrologic conditions

between the two areas that supported different microbial communities with respect to contaminant degradation prior to oxygen-based remediation. For example, although fuel-contaminated ground water down-gradient of the source area was anoxic, infiltration of DO-rich recharge occurred through overlying permeable sediments for some time before oxygen injection. In contrast, this natural input of DO does not occur in the paved, former UST area. Moreover, the absence of recharge in the source area permitted the accumulation of reduced mineral- and soluble-inorganic species, a significant oxygen sink that competed with contaminant biodegradation demand for the injected oxygen. This talk will describe the relation that exists between hydrologic and microbiologic conditions in contaminated shallow ground-water systems exhibited at this site, and why certain parameters should be measured as part of any oxygen-based remedial strategies.

H72D-0881 1330h POSTER

Effect of Redox Conditions on MTBE Biodegradation in Surface-Water Systems

Paul M Bradley¹ (803-750-6125; pbradley@usgs.gov)

Francis H Chapelle¹ (803-750-6116; chapelle@usgs.gov)

James E Landmeyer¹ (803-750-6128; jlandmeyer@usgs.gov)

¹U.S. Geological Survey, 720 Gracern Rd, Ste 129, Columbia, SC 29210, United States

Microbial degradation of methyl t-butyl ether (MTBE) was observed in surface-water-sediment microcosms under anaerobic conditions. However, the efficiency and products of anaerobic MTBE biodegradation were strongly dependent on the predominant redox conditions. In the presence of substantial methanogenic activity, MTBE biodegradation was nominal and involved reduction of MTBE to the toxic product, t-butanol (TBA). In the absence of significant methanogenic activity, accumulation of 14C-TBA generally decreased and mineralization of [U-14C] MTBE to 14CO₂ generally increased as the oxidative potential of the predominant terminal electron acceptor increased. The results of this study indicate that microorganisms inhabiting the bed sediments of streams and lakes can degrade MTBE effectively under a range of anaerobic terminal electron accepting conditions. Thus, anaerobic bed sediment microbial processes may provide a significant environmental sink for MTBE in surface water systems throughout the United States.

H72D-0882 1330h POSTER

Support Vector Machines (SVMs) Approximation of Flow and Transport Models in Initial Groundwater Contamination Detection Monitoring Network Design

Tirusew Asefa¹ (435-797-3149; tasefa@cc.usu.edu)

Marius Kemplowski¹ (435-797-3192; mkem@cc.usu.edu)

¹Utah Water Research Lab, 8200 Old Main Hill, Logan, UT 84321, United States

In this paper we present the application of a new statistical learning methodology called Support Vector Machines (SVMs). SVMs are learning systems that use a hypothesis space of linear functions in a Kernel induced higher dimensional feature space, trained with learning algorithm from optimization theory. They are based on a principle that aims at minimizing a bound on the generalization error model, rather than the mean square error over a training set. Due to Mercer's conditions on the kernels the corresponding optimization problems are convex and hence have no local minima. In this research SVMs are used to simulate Monte-Carlo based flow and transport models for the design of detection monitoring system. The objectives of the exercise are maximizing the probability of detecting contaminants that exceed some regulatory standard before reaching compliance boundary while minimizing cost (i.e., number of monitoring wells). Application of the method at a generic site showed a promising performance. The SVM was trained using 500 samples generated from 200 Monte Carlo flow and transport realizations. SVM selected best configurations of networks of wells were identical with the one obtained from the physical model while the reliability provided by the respective networks differ slightly.

H72D-0883 1330h POSTER

NAWQA: Water-Quality Insights Learned in the Last 10 Years

Timothy L Miller¹ (703-648-6868; tlmiller@usgs.gov)

William G Wilber (703-648-6878; wgwilber@usgs.gov)

Pixie A Hamilton (804-261-2602; pahamilt@usgs.gov)

¹U.S. Geological Survey, 413 National Center 12201 Sunrise Valley Dr., Reston, VA 20192, United States

The first decade of studies (1991-2001) by the U.S. Geological Survey National Water-Quality Assessment (NAWQA) Program provides significant new findings about the quality of our Nations streams and ground water. Comprehensive assessments of pesticides, nutrients, volatile organic compounds (VOCs), trace metals, and aquatic ecology are developed at the national scale through synthesis and analysis of findings in 51 NAWQA study units (major river basins and aquifer systems). These assessments characterize the ambient water resource the source of about 60 percent of the Nations drinking water, as well as water for industrial, irrigation, and recreational uses. Each assessment is an interdisciplinary and long-term evaluation of the total resource, rather than of a specific geographic area or problem at a single point in time. Therefore, the findings describe the general health of water resources, and reveal current and emerging water issues.

Collectively, the NAWQA assessments indicate that the Nations waters are generally suitable for irrigation, drinking water supply, and other home and recreational use. Comparisons of findings among the basins, however, reveal several major challenges and common issues in nearly every basin. First, the water in agricultural and urban areas has a characteristic chemical makeup or signature that is closely linked to the chemicals used. Some of the highest concentrations of nitrogen and herbicides (such as atrazine, metolachlor, alachlor, and cyanazine) were detected in samples collected from agricultural areas with the highest chemical use. Insecticides most commonly diazinon, carbaryl, malathion, and chlorpyrifos occurred more frequently and usually at higher concentrations in urban than in agricultural streams. All urban streams had concentration of insecticides exceeding at least one guideline established to protect aquatic life.

Second, streams and ground water in basins with significant agricultural or urban development almost always contain complex mixtures of pesticides, VOCs, and nutrients. For example, more than 70 percent of stream samples collected in agricultural and urban areas contained 5 or more pesticides, and nearly 25 percent of all ground-water samples contained two or more. In addition, chemical breakdown products, which can have similar or even greater toxicities than parent compounds, are often as common as parent compounds.

Third, comparisons among NAWQA assessments indicate that contaminant concentrations vary from season to season and among watersheds because of differences in land and chemical use, land-management practices, degree of watershed development, and natural features. Seasonal patterns were found in most basins, mainly reflecting the timing and amount of chemical use, the frequency and magnitude of runoff from rainstorms and snowmelt, and specific land-management practices. Typically, lengthy periods of low concentrations of contaminants are punctuated by seasonal pulses of much higher concentrations. Natural features, such as geology, hydrology, and soils, and land-management practices, such as tile drainage and irrigation, affect the movement of water and chemicals over land and into aquifers, and, thereby, govern a water body's vulnerability to contamination. Concentrations of contaminants can therefore vary significantly in different regions of the Nation, or even locally within a basin, despite seemingly similar land-use settings and chemical use.

URL: http://water.usgs.gov/nawqa/nawqa_home.html

H72D-0884 1330h POSTER

A Low-Level Real-Time In Situ Monitoring System for Tritium in Groundwater and Vadose Zone

James T Santo¹ (505-424-6955; jsanto@seabase.com)

Daniel G Levitt¹ (5054246955; dlevitt@seabase.com)

¹Science and Engineering Associates, Inc., 3205 Richards Lane, Suite A, Santa Fe, NM 87507, United States

Tritium is a radioactive isotope of hydrogen produced as a by-product of the nuclear fuel cycle. It is also an integral part of the nuclear weapons industry and has been released into the environment through both the production and testing of nuclear weapons. There are many sites across the DOE complex where tritium has been released into the subsurface through the disposal of radioactive waste and at the Nevada Test Site, through the underground testing of nuclear weapons. Numerous DOE facilities have an on-going regulatory need to be able to monitor tritium concentrations in groundwater within deep hydrologic zones and in the shallower non-saturated vadose zone beneath waste disposal pits and shafts and other release sites. Typical access to groundwater is through deep monitoring wells and situated in remote locations. In response to this need, Science & Engineering Associates, Inc. (SEA) and its subcontractor, the University of Nevada Las Vegas (UNLV) Harry Reid Center (HRC) for Environmental Studies has conducted the applied

research and engineering and produced a real time, in situ monitoring system for the detection and measurement of low levels of tritium in the groundwater and in the shallower vadose zone. The monitoring system has been deployed to measure tritium in both the vadose zone near a subsurface radioactive waste package and the groundwater in a deep hydrologic reservoir at the Nevada Test Site. The monitoring system has been designed to detect tritium in the subsurface below federal and/or state regulatory limits for safe drinking water and has been successfully demonstrated. The development effort is being funded through the U.S. Department of Energy, National Energy Technology Laboratory and the DOE Nevada Operations Office Advanced Monitoring Systems Initiative (AMSI).

H72D-0885 1330h POSTER

Radon as a Natural Partitioning Tracer for Locating and Quantifying DNAPL Saturation in the Subsurface

Brian M Davis¹ (541-737-8870; davisbri@engr.orst.edu)

Jack Istok¹ (541-737-8547; jack.istok@orst.edu)

Lewis Semprini¹ (541-737-6895; lewis.semprini@orst.edu)

¹Dept. of Civil, Construction, and Environmental Engineering, Oregon State University, 202 Apperson Hall, Corvallis, OR 97331, United States

The inability to locate and quantify dense nonaqueous phase liquid (DNAPL) saturation in the subsurface presents obstacles to site characterization and remediation. The objective of this study is to evaluate the use of naturally occurring radon as an in-situ, partitioning tracer to locate and quantify DNAPL saturation. In the saturated zone, radon emanating from aquifer solids occurs as a dissolved gas and, due to its non-polarity, partitions into DNAPL. Partitioning between the DNAPL and aqueous phases results in retarded radon transport during groundwater flow. The radon retardation factor can be determined using single-well 'push-pull' tracer tests, enabling the calculation of the DNAPL saturation. Radon can also be used as a 'static' partitioning tracer, whereby grab samples of radon from monitoring wells in contaminated and non-contaminated portions of an aquifer are collected and compared to calculate the DNAPL saturation and to monitor saturation changes as remediation proceeds.

The utility of these methods was investigated in the laboratory using a physical aquifer model (PAM). Static and push-pull tests were performed before and after contamination of a portion of the PAM sediment pack with trichloroethene (TCE). The PAM was then remediated using alcohol cosolvent and tap water flushes, and static and push-pull tests were performed to assess the efficacy of remediation. Numerical simulations were used to estimate the retardation factor for radon in the push-pull tests. Radon partitioning was observed in static and push-pull tests conducted after TCE contamination. Calculated TCE saturations ranged up to 1.4 % (static test) and 14.1 % (push-pull test), based on the numerical method modeling approach used to analyze the results. Post-remediation tests showed decreases in TCE saturations. The results show that radon is sensitive to changes in DNAPL (e.g., TCE) saturation in space and time. Recent advances in numerical modeling of radon in push-pull tests have shown the influence of TCE saturation distribution and initial radon concentrations on radon breakthrough curves and calculated TCE saturations. These advances have led to more accurate predictions of the TCE saturation in the PAM.

The push-pull method was applied at a field site at Dover Air Force Base, Delaware. The site consists of an aquifer 'test cell' 27 ft long and 18 ft wide surrounded by steel pilings to a clay confining unit 40 ft below grade. Push-pull tests were performed before and after contamination of the test cell with perchloroethene (PCE). Push-pull tests performed before contamination showed no evidence of radon retardation, while tests performed after contamination showed evidence of retardation and suggested the presence of PCE.

H72D-0886 1330h POSTER

Arsenic in Bangladesh Groundwater: Where it Comes From and why

Y. Zheng^{1,2} (yzheng@ldeo.columbia.edu); A. van Geen²; M. Stute²; R. Dhar¹; Z. Mo¹; Z. Cheng²; A. Horneman²; H. J. Simpson²; I. Gavrieli^{2,3}; K. M. Ahmed⁴

¹SEES, Queens College, Flushing, NY 11367, United States

²Lamont-Doherty Earth Observatory of Columbia University, Rt. 9W, Palisades, NY 11367, United States

³Geochemistry, Geol. Survey of Israel, Jerusalem 95501, Israel

⁴Dept. of Geol., Dhaka Univ., Dhaka 1000, Bangladesh

Arsenic (As) is a highly toxic, ubiquitous metalloid and realization is growing that water-borne As now poses a significant threat to human and ecosystem health worldwide. Elevated concentrations of As in groundwater have emerged as a major health threat in the Ganges-Brahmaputra Delta region where tens of millions of people are exposed to [As] 10 to 100 times higher than the drinking water standard of 10 µg/L recommended by the WHO. Extensive sampling by the British Geological Survey has shown that water from shallow aquifers with recent alluvial sediments carries distinctly higher [As] than does water from deeper aquifers with presumed pre-Holocene sediments. However, the reasons why such a large contrast in [As] exists between younger, Holocene aquifers and older, Pleistocene aquifers are not well understood. Furthermore, although As is generally believed to be of natural origin and is mobilized in reducing groundwater, the sources of particle phase As and mechanisms of arsenic release to groundwater remain poorly understood.

Hydrological and geochemical factors contributing to elevated arsenic concentrations (up to 800 µg/L) in the shallow aquifers and much lower [As] (< 50 µg/L) in the deep aquifers were investigated in two villages (~1 km² each) in Arai-hazar upazilla, Bangladesh. Arai-hazar is on the margin of the Holocene Meghna fluvial floodplain where the transition occurs from the uplifted mid Pleistocene Madhupur tract to much younger, incised Meghna river channel deposits from west to east. Coring confirmed that the aquifers were separated by a multiple-layered silt/clay section. At least at one site, radiocarbon dating of peat layers within the silt/clay section suggests that a Holocene aquifer is unconformably overlying a Pleistocene sequence. Based on radiocarbon and tritium dating, the residence time of groundwater in the high-As shallow, Holocene aquifers (4 - 30 m) is years to decades, much less than that of the low-As deep aquifer (50- 100 m), which is a thousand to tens of thousands of years. This hydrological separation is important in preventing water from the high-As shallow aquifer from entering the low-As deep aquifer.

Major differences in reducing conditions, when combined with a widely dispersed sedimentary source of As most likely sorbed on amorphous Fe oxyhydroxide contributes to the contrast between the high-As shallow aquifer and the low-As deep aquifers. High concentrations of NaH₂PO₄ extractable As (up to 5 mg/kg), and HCl-extractable Fe (up to 4.1 g/kg) were found at 4-10 m intervals of reducing groundwater enriched in As in the shallow aquifer. Sediments from deeper aquifers had lower NaH₂PO₄ extractable As (~ 0.4 mg/kg), probably accounting for the low [As] groundwater, despite of strongly reducing conditions at one site. At another site, groundwater displayed positive oxidation-reduction potential (ORP) values as well as low NaH₂PO₄ extractable As (0.1 - 1 mg/kg), therefore no As mobilization would be expected. In the shallow aquifer, As is released from reductive dissolution of Fe-oxyhydroxides with a sediment As/Fe ratio of 20 mmole/mole, based on As/Fe ratios of groundwater samples that followed a generally increasing As and Fe concentrations with decreasing ORP values. This As/Fe ratio of 20 mmole/mole is much higher than that leached from the high As, sandy sediment (~ 1 mmole/mole), suggesting that Fe oxyhydroxide that was reductively dissolved, is much more enriched in As than the bulk composition of phases which are leachable from the sediments.

H72D-0887 1330h POSTER

Spatial and temporal occurrence of bacterial pathogens in rural water supplies, Southern Alberta, Canada

Victor Gannon¹ (403 382 5514; gannonv@inspection.gc.ca); Tom a. Graham¹ (403 382 5524); Susan Read²; Kim Ziebell²; Ann Muckle²; James Thomas³; Brent Selinger³; Stefan Kienzle³ (403 382 1875; stefan.kienzle@uleth.ca); Suzan L. Lapp³; Ivan Townshend³ (403 329 2226); James Byrne³ (403 329 2002; byrne@uleth.ca)

¹Laboratory for Foodborne Zoonoses, Population and Public Health Branch, Health Canada, Lethbridge, AB T1K 3M4, Canada

²Laboratory for Foodborne Zoonoses, Population and Public Health Branch, Health Canada, Health Canada, Guelph, ON N2L 1G4, Canada

³University of Lethbridge, Department of Geography, Lethbridge, AB T1K 3M4, Canada

Southern Alberta has the highest rate of gastrointestinal illness in the province, and some of the highest infection rates in Canada. The region has extensive field crop irrigation system supporting a rapidly expanding animal agriculture industry. Recently, there has been much public concern about the safety and quality of water in this region, particularly with respect to drinking water supplies for farm residences and rural communities, where water treatment may be less than optimal.

We have tested raw river and irrigation water in the Oldman River Basin in southern Alberta for the presence of bacterial pathogens (*E. coli* O157:H7 and *Salmonella* spp.) as well as made counts of total and faecal coliforms over the last two years (2000-2001). *E. coli* O157:H7 and *Salmonella* spp. isolations and coliform counts peak in raw water from this system during the summer months. *E. coli* O157:H7 was only isolated from 27/1624 (1.7%) and *Salmonella* was isolated from 158/1624 (9.7%) of raw water samples over the two year period. Certain sites had multiple pathogen isolations and high indicator bacteria counts in the same year and from year to year. Certain sites had multiple pathogen isolations and high indicator bacteria counts in the same year and from year to year. *S. Rubislaw* was the most common *Salmonella* serovar isolated in both years. While this serovar is rarely associated with human or animal disease in Alberta, other *Salmonella* serovars isolated, such as Typhimurium, are commonly disease-associated.

This poster presents initial analyses of the spatial and temporal properties of pathogen occurrences in the Oldman Basin in 2000 and 2001. Seasonal variability in the occurrence of pathogens is particularly interesting and of concern. Early results demonstrate the pathogen occurrences peak during the height of the summer recreation season; posing a substantial infection risk for the public and tourism populations. Human consumption of inadequately treated water in this region, especially during summer months represents a significant risk of infection with *E. coli* O157:H7, *Salmonella* spp and likely other enteric pathogens. There are also likely to be risks associated with water application for irrigation and processing of raw edible plants. Consumption of untreated waters by animals is likely to maintain this pathogen in this reservoir. The information generated in this study should be useful in designing optimal public health intervention strategies.

H72D-0888 1330h POSTER

Study of Disinfection By-Products and Long Term Storage of Drinking Water.

Greta McGee¹ (907-474-5397; ftgmm@uaf.edu)

Dan White¹ (907-474-6222; ffdmw@uaf.edu)

Sarah Garland¹ (907-474-1513; ffdsg@uaf.edu)

¹Water Environmental Research Center/UAF, 306 Tanana Drive Duckering Rm 525, Fairbanks, AK 99775, United States

One of the challenges facing many of Alaskan communities is providing safe and reliable drinking water from sources containing high concentrations of natural organic material (NOM). These highly colored waters, locally referred to as tundra tea, often result in the formation of disinfectant byproducts during treatment. Since surface water sources in the Arctic are often frozen for 6-9 months per year, communities are often forced to either store raw water for treatment during the winter or treat and store enough drinking water during the summer to last through the winter.

Because long-term storage practices are somewhat unique to water treatment in the rural Northern communities, the practice has not been thoroughly studied and there is limited published information on how water quality is affected by extended storage. Anecdotal evidence and data collected by field engineers indicate that significant changes are occurring and that the quality of the treated water can be adversely impacted.

The University of Alaska Small Drinking Water System Technical Assistance Center (ATTAC) is conducting fundamental and applied research to help Alaskan small communities provide safe and reliable drinking water. One research focus area is the formation of disinfection by-products (DBPs) in small drinking water systems. Studies to characterize the NOM present in Alaskan surface waters and demonstrations of NOM removal technologies have been conducted over the past several years. The study presented here examined the formation of disinfection by-products during long-term storage of water from five small Alaskan water systems. Results from this research suggest that long-term storage has a significant impact on DBP formation. The results suggest that the NOM escaping treatment is likely to react in the storage tank resulting in DBP concentrations that are well above the estimated DBP formation potential.

H72D-0889 1330h POSTER

A new thermo-hydrodynamic method for estimating convective heat flux associated with vertical fluid migration.

Oleksandr Fialko¹ (380-44-261-4963; fial@mail.univ.kiev.ua)

Lyubov Kovalchuk¹

¹Kiev National University, Dept. of Geology 90 Vasilkovskaya st., Kiev 03127, Ukraine

Ample field observations in areas of known oil and gas deposits reveal an existence of excess temperature anomalies associated with the hydrocarbon-bearing structures. These observations are explained in terms of upward migration of heated fluids. In this case there is a deviation from a linear temperature distribution with depth due to a convective component of the heat flux. We propose a new method based on in situ measurements of the thermal field that allows one to take into account both conductive and convective components of the heat flow. In addition to the usual measurements of temperature, we determine the curvature of the geothermograms, which characterizes the degree of deviation of the heat transfer from a conductive regime. Correspondingly, in addition to the commonly used geothermal gradient, we introduce new parameters, such as the radius of curvature of the geotherms (R), the coefficient of curvature of the geotherms (K), the Knudsen criterion (Kn), and parameter F. We present analytic expressions for the determination of these parameters, and evaluate these parameters for several natural objects. We demonstrate the usefulness of the proposed method for 1) forecasts of the presence of the deep-seated hydrocarbon deposits; 2) estimates of the abnormally elevated gas content in the deep-seated coal deposits, and determination of zones with high risk of methane bursts; 3) studies of the hydro-geothermal conditions of the geothermal areas; 4) determination and localization of leaks along the buried industrial pipelines. We present examples illustrating the application of our method for the above-mentioned tasks.

H72D-0890 1330h POSTER

Oxidation of Framboidal Pyrite as a Mobilization Mechanism During Upper Storage and Recovery in the Upper Floridan Aquifer, Southwest Florida

Roy E Price¹ (813-974-8358; royprice42@hotmail.com)

Thomas Pichler¹ (813-974-0321; pichler@chuma.cas.usf.edu)

¹University of South Florida, 4202 E Fowler Ave SCA 532, Tampa, FL 33543, United States

During a recent study conducted at the University of South Florida, core samples were collected from 20 wells located in the southern half of the Southwest Florida Water Management District (SWFWMD), and analyzed to gain a better understanding of arsenic distribution and mineralogy throughout the Oligocene-aged Suwannee Limestone, Upper Floridan Aquifer. The Suwannee is the primary storage zone utilized to date for Aquifer Storage and Recovery (ASR), the process of capturing excess water during the rainy season and storing that water underground until needed. The SWFWMD recently determined that ASR is a critical component for its 20-year strategy to enhance water supply in southwest Florida where, as of January 2002, 26 facilities are in operation and 19 are permitted for construction. The Comprehensive Everglades Restoration Project (CERP) calls for over 330 ASR wells to store 1.7 billion gallons of water per day. This research was conducted because of the discovery of elevated arsenic (As) levels during recovery cycle testing of several ASR facilities throughout southwest Florida.

Before any solution or mobilization mechanism can be suggested, the exact mineralogical association of the arsenic must be determined. Possible sources for the arsenic include: 1) sulfide minerals, 2) iron oxyhydroxide coatings, 3) organic material, and/or 4) phosphate nodules. Sampling was carried out with the purpose to sample each core at constant intervals and to collect samples at locations that may have a higher potential for the presence of arsenic, such as fractures, organic material, sulfide-rich zones and iron oxyhydroxide-rich zones. Detailed lithologic descriptions for each sample showed that framboidal pyrite was present, and in fact abundant, throughout the unit, while the iron oxides, organics, and phosphate nodules were uncommon. Total arsenic concentrations for each sample were determined by hydride generation-atomic fluorescence spectrometry (HG-AFS), which showed much higher values for arsenic in the Suwannee Limestone than previously reported. In addition, the distribution of arsenic throughout the Suwannee Limestone was found to be very heterogeneous. Samples with concentrations in excess of 20 ppm arsenic were then chosen for analysis by SEM and Electron Probe Microanalyzer, equipped with EDS and WDS capabilities respectively, with the intent to further constrain the mineralogical arsenic association in each sample. Phosphate nodules and organic material did not contain detectable amounts of arsenic, while more than 85% of framboids analyzed were found to contain as much as 2 wt %. Iron oxides, where present, contained arsenic, but we believe iron oxide in the subsurface would not occur and has precipitated as a result of the oxidation of pyrite.

H72D-0891 1330h POSTER

Perchlorate Sorption/Transformation from Solution Using Activated Carbon.

Ellen L Pyatt^{1,2} ((530) 219-4953; elpyatt@ucdavis.edu)

Alan P Jackman² ((530) 752-8777; apjackman@ucdavis.edu)

Dennis Rolston¹ ((530) 752-2113)

¹ Land Air and Water Resources University of California Davis, One Shields Avenue, Davis, CA 95616, United States

² Chemical Engineering and Material Science, One Shields Avenue, Davis, CA 95616, United States

Because perchlorate (ClO₄⁻) inhibits iodide uptake it is a contaminant of concern in groundwater. Therefore ClO₄⁻ contaminated drinking water must be treated to either remove ClO₄⁻ or reduce ClO₄⁻ to chloride (Cl⁻). Batch and column experiments using varying operational conditions with powdered activated carbon (PAC) and granular activated carbon (GAC) were performed to evaluate PAC and GAC capacity to adsorb ClO₄⁻ and/or reduce ClO₄⁻ to Cl⁻, chlorite (ClO₂⁻) and chlorate (ClO₃⁻). Varying operational conditions were particle size, pH, and ClO₄⁻ salt cation. ClO₄⁻ adsorption was affected by particle size, pH, and cation salt. ClO₄⁻ adsorption on PAC and GAC is partially reversible.

H72E MCC: Hall C Sunday 1330h Remote Sensing of Land Surface Hydrological Processes Posters (joint with GC)

Presiding: V Lakshmi, University of South Carolina; T Cahill, Texas AM University

H72E-0892 1330h POSTER

Dew and Intercepted Precipitation: Invisible at 1.4 GHz?

Brian K. Hornbuckle^{1,2} (734-615-6314; buckle@umich.edu)

Anthony W. England^{1,2} (734-763-5534; england@umich.edu)

¹ University of Michigan, Dept of Atmospheric, Oceanic, and Space Science, Space Research Bldg 2455 Hayward St, Ann Arbor, MI 48109-2143, United States

² University of Michigan, Dept of Electrical Engineering and Computer Science, EECS Bldg 1301 Beal Ave, Ann Arbor, MI 48109-2122, United States

Soil moisture, vegetation temperature, and vegetation moisture all strongly influence the fluxes of heat and water at the land-atmosphere interface. At sufficiently low column densities, the microwave brightness of a vegetated surface is most sensitive to the water content of the first few centimeters of the soil. On the other hand, at high column densities sensitivity to vegetation temperature and moisture dominates. What are the relative effects of soil moisture, vegetation temperature, canopy moisture content, and canopy water, either in the form of intercepted precipitation or dew, on the microwave brightness?

We begin to answer this question with observations of 1.4 GHz brightness, soil moisture, soil and canopy temperatures, precipitation, wind speed, and radiative fluxes made in a field of corn. We find that when the corn is mature and at its highest level of column density, there is still meaningful sensitivity to soil moisture. Three different states of canopy water (a night with no dewfall, a night with approximately 0.1 mm of dew, and a night with a 21 mm precipitation event) captured in our data set reveal that the net effect of canopy water is a decrease in the brightness temperature. In other words, volume scattering in the vegetation is enhanced more than emission by canopy water. Furthermore, at high column densities, sensitivity to soil moisture and canopy water are of the same order of magnitude. If neglected, intercepted precipitation or dew will make the soil appear to be wetter than it actually is.

URL: <http://www.eecs.umich.edu/grs>

H72E-0893 1330h POSTER

Estimation of Land Surface Window (8-12 μm) Emissivity from Multi-Spectral Thermal Infrared Remote Sensing - A Case Study in a Part of Sahara Desert

Kenta Ogawa¹ (kenta@hydrolab.arsusda.gov)

Thomas Schumgge¹ (schumgge@hydrolab.arsusda.gov)

Frederic Jacob¹ (fjacob@hydrolab.arsusda.gov)

¹ USDA/ARS Hydrology and Remote Sensing Lab, Bldg 007, BARC-West, Beltsville, MD 20705, United States

Land surface window (8-12 μm: 800-1250 cm⁻¹) emissivity is an important parameter for estimating the longwave surface energy balance. The window emissivity can vary significantly, because the spectral emissivity ranges from 0.7 to 1.0 for bare soils and rocks in this range. Because the large part of the earth's total radiative emission is lost directly to space within the 8-12 μm region, the knowledge of the surface emissivity is crucial in the study of earth-atmosphere system radiation budget. Several studies have been made to map the window emissivity using a global land classification map (surface type map) and corresponding emissivity calculated from spectral libraries. The advantage of this method is that it is possible to obtain global map. However, wide spatial variations of emissivity can be observed in rocks and soils, which are recognized as one only surface type such as barren or bare soil in the classification map.

This study focuses on estimating the window emissivity from the emissivities of the five channels on the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). ASTER is a sensor onboard the Earth Observing System (EOS) Terra satellite launched in 1999, and has five channels in the thermal infrared region (8-12 μm). Using this sensor, it is possible to estimate surface spectral emissivity for each channel at a spatial resolution of 90 m globally. A multiple regression was used to relate the five ASTER emissivities to the window emissivity. This regression was developed using two spectral libraries, ASTER Spectral Library and MODIS Emissivity Library. The window emissivities ranged from 0.80 to 0.99 for natural surfaces, such as, rocks, soils, vegetation, water, ice, and snow. The RMS error of the estimated window emissivity was less than 0.01 both in calibration and in validation.

We applied this calibrated regression to emissivities computed using ASTER data acquired in 2001 and 2002 over a 240 km by 1200 km area in Sahara Desert, Africa. We compared the estimated window emissivities derived from regression with the ones expected from the classification map and found significant difference ranging from -0.08 to +0.07.

H72E-0894 1330h POSTER

Estimation of Watershed Scale Soil Moisture from Point Measurements in SMEX02

Michael H Cosh¹ (mcosh@hydrolab.arsusda.gov)

Thomas J Jackson¹ (tjackson@hydrolab.arsusda.gov)

Rajat Bindlish¹ (bindlish@hydrolab.arsusda.gov)

John Prueger² (prueger@nsl.gov)

¹ USDA-ARS Hydrology and Remote Sensing Laboratory, Building 007 Room 104 BARC-West, Beltsville, MD 20705, United States

² USDA-ARS National Soil Tilth Laboratory, 2150 Pammel Drive, Ames, IA 50011, United States

Understanding watershed scale soil moisture distributions is necessary to validate current remote sensing, such as the Advanced Microwave Scanning Radiometer (AMSR). Unfortunately, remote sensing technology does not currently resolve the land surface at a scale that can be easily validated with ground observations. One method of validation uses existing soil moisture measurement networks and scales up to the resolution of these remote sensing footprints. Soil Moisture Experiment 2002 (SMEX02) was an excellent opportunity to implement one such soil moisture gaging system which, when calibrated, provided robust estimates of the watershed scale soil moisture throughout the summer of 2002. Twelve fields distributed across the Walnut Creek watershed were instrumented with in situ soil moisture probes and were intensively sampled during the experiment, between June 25 and July 12, 2002. The sampling sites were analyzed for temporal stability and scaling relationships were developed. These point measurements were scaled up to the field scale (~800 m) and then to the watershed scale (~25 km) for the field experiment period and were shown to be accurate indicators of the large-scale soil moisture distribution. Point measurements were then used as a basis for a watershed estimate for several months beyond SMEX02, thereby providing a long record of watershed scale soil

moisture which can be used for validation. The ability to estimate the soil moisture is measured by a variety of techniques, including split sample verification. This analysis is a first step in the implementation of large-scale soil moisture validation utilizing networks such as the Soil Climate Analysis Network (SCAN) as a basis for calibrating soil moisture satellite products.

H72E-0895 1330h POSTER

Spatial Classification Techniques for Synthetic Aperture Radar

Perry J. LaPotin¹ (1-802-695-1430; perry@science.uva.nl)

Michael F. Masuch¹ (31-20-422-9767; michael@science.uva.nl)

Joel D. Schlage² (1-603-646-4387; joel@rsgisc.crrrel.usace.army.mil)

George A. Aliev³ (7-812-542-1244; vova@anw.ru)

¹ University of Amsterdam, Applied Logic Laboratory, 57 Plantagekade, Amsterdam 1018 ZV, Netherlands

² USACRREL, Remote Sensing/GIS Center, 72 Lyme Road, Hanover, NH 03755, United States

³ IAELPS Academician, 3 UI. Gelsingforsskaya, St. Petersburg 194044, Russian Federation

In this paper, we examine new methods for the classification of single frequency C-band Synthetic Aperture Radar (SAR) data using trigonometric functions to segment the information into primary band composites. The decomposition is shown to be scaleable from the complex series representation to a simple addition of real and imaginary terms. A condensed example is provided for four filter elements in the standard orientation. This example shows the spatial and radiometric classification of a meandering river system using the radiometric and spatial filters. A discussion of the primary effects is given with a complete derivation for the filter design, the transfer functions, and the related scalar applications.

H72E-0896 1330h POSTER

Spatial Variability in Radiant Stream Temperatures Estimated From Thermal Infrared Images

Rebecca N Hancock¹ (206-543-6229;

RebeccaH@u.washington.edu); Keith A Cherkauer² (206-543-0423; cherkaue@u.washington.edu);

Jennifer E Kay¹ (206-543-6221;

jenkay@u.washington.edu); Alan Gillespie¹ (206-543-6229; alan@rad.geology.washington.edu);

Stephen J Burges² (206-543-7135;

sburges@u.washington.edu); Derek B Booth² (206-543-0423; dbooth@u.washington.edu)

¹ University of Washington, Department of Earth and Space Sciences, Seattle, WA 98195-1310, United States

² University of Washington, Department of Civil and Environmental Engineering, Seattle, WA 98195-2700, United States

Stream temperature is an important water quality indicator, for example, in the Pacific Northwest where endangered fish populations are sensitive to elevated water temperature. Regional assessment of stream temperature is limited by sparse sampling of temperatures in both space and time. Remotely sensed thermal infrared (TIR) imagery can be used to derive spatially distributed estimates of the radiant skin temperature (Tr) (top 100 nm) of streams, but spatial variability in these measurements makes it difficult to link Tr to the kinetic temperature of the stream (Tk). In image pixels that are fully resolved at the scale of the TIR data, this along-stream variability is primarily the result of evaporative cooling due to wind, and to surface effects along the stream, such as riffles and foam, which increase the apparent emissivity and therefore the measured radiance. The resulting distinct spatial pattern of Tr must be identified and corrected if accurate Tk is to be determined. We investigate spatial variability in Tr using medium-resolution (5m) TIR imagery from the airborne NASA-MASTER sensor, and coarse-resolution (90m) imagery from the ASTER sensor on the Terra satellite. Ground data of Tr and Tk within the Yakima River watershed in Washington State are used to validate analysis results. In a uniform reach with a Tk of 20.7 °C, the mean Tr observed using MASTER is 22.1 °C, with a standard deviation of 0.7 °C. Preliminary results show that the distinct along-stream patterns of Tr correspond to observed surface effects.

URL: <http://depts.washington.edu/strtemp/>