WWRC-95-19

THE 1995 ROCKY MOUNTAIN GROUNDWATER CONFERENCE

Science & Policy:
Who's Driving Groundwater Management?

October 4, 5, 6, 1995
Snow King Resort
Jackson Hole, Wyoming

Agenda and Abstracts

Organized and hosted by:

Wyoming Water Resources Center, Groundwater Research Cluster, University of Wyoming

Montana Water Resources Center, Center for Biofilm Engineering, Montana State University

Acknowledgements

Supporters:

Energy Laboratories, Billings, MT
MSE Inc., Butte, MT
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Cooperators:

Wyoming State Engineer's Office
Montana Bureau of Mines and Geology
Wyoming Department of Environmental Quality
Wyoming Water Development Commission
Montana Department of Agriculture
Wyoming State Geological Survey
U. S. Geological Survey—Wyoming District
Idaho Water Resources Research Institute

Exhibitors:

Energy Laboratories, Billings, MT
ORS Environmental Systems, Littleton, CO
Ted D. Miller & Associates, Lakewood, CO
Intermountain Environmental, Logan, UT
Inter-Mountain Laboratories, Bozeman, MT

AGENDA

Tuesday, October 3, 1995

8:00 - 5:00 p.m. **EPA Region VIII States' Meeting** **Summit I**

Presentation of State Programs and Experiences regarding Regulation of Groundwater Quality

EPA has been asked to look at reinventing environmental regulations. With expected cuts, EPA has been asked to become more effective and efficient and to delegate to the states as much as possible. Some of the states are also experiencing budget shortfalls and have been asked to improve efficiency and effectiveness and prioritize groundwater protection efforts. This meeting is expected to provide a summary of state groundwater programs and allow for an assessment of their programs. Each state has also been asked to comment on potential methods, if available, that they would use to improve groundwater protection programs. This will allow states to gain from other states experiences with administration and funding strategies.

Each of the six states in EPA Region VIII will provide approximately a one-hour presentation explaining their state's groundwater protection program. After completion of each state's presentation, a short period of time will be allowed for discussion and questions from other states and the audience.

The meeting will be open to interested persons and any input would be appreciated.

3:30 - 5:30 p.m. **Registration** **Hotel Lobby**

Wednesday, October 4, 1995

7:30 a.m. **Registration** **Hotel Lobby**

7:30 a.m. **Continental Breakfast** **Teton Mezzanine**

8:15 a.m. **Welcoming Remarks** **Grand Room**

- Steven P. Gloss, Director, Wyoming Water Resources Center, University of Wyoming
- Peter M. Jorgensen, President, Jorgensen Engineering, Member, Board of Trustees, University of Wyoming

Introduction to Conference

- Dorothy Bradley, Director, Montana Water Resources Center, Montana State University

8:30 - 12:00 p.m. **PLENARY SESSION** **Grand Room**

Science & Policy: Who's Driving Groundwater Management?

Moderator: **Jo Ellen Darcy**, Professional Staff, Environment and Public Works Committee, U.S. Senate

Speakers:

- **James Mercer**, President, GeoTrans, Inc. and Vice-Chair, National Research Council, Committee on Groundwater Cleanup Alternatives
  Overview of the findings and recommendations of the National Research Council's Committee on Groundwater Cleanup Alternatives.

- **William Yellowtail**, Regional Administrator, U.S. Environmental Protection Agency, Denver, CO
  What has EPA faced in implementing the requirements of CERCLA? Is there an appropriate balance between national, state, and local opinions in CERCLA? What is the position of EPA vis-a-vis reauthorization?

- **Rich Innes**, Director of Federal Affairs and National Government Affairs, Browning-Ferris Industries, Washington, DC
  What is the congressional perspective regarding reauthorization? Which changes are likely? How effective has the Superfund been from a congressional view? Does Congress get good information on the state of the science and technology?

10:00 - 10:15 a.m. **BREAK** **Teton Mezzanine**

- **Sandy Stash**, Montana Facilities Manager, ARCO, Inc., Anaconda, MT
  A perspective on Superfund and related issues from the point of view of a regulated industry.

- **Chris Shuey**, Southwest Research and Information Center, Albuquerque, NM
  How well has CERCLA served the public interest? What changes could or should be made in reauthorization to improve citizen participation opportunities in CERCLA?

- **Richard Ewing**, Dean, College of Sciences and Director, Institute for Scientific Computation, Texas A & M University, College Station, TX
  A discussion of the state of current science and technology vis-a-vis what is currently required by CERCLA and what should be addressed in reauthorization.

- **Bonnie Lovelace**, Coal and Uranium Bureau, Department of Environmental Quality, Helena, MT
  Groundwater and the coal industry — a state regulator's perspective.

12:00 - 1:30 p.m. **Lunch provided** **Teton Room**

1:30 - 5:00 p.m. **Concurrent Sessions A, B, & C**

A. FATE AND TRANSPORT **Timberline I**

Moderator: Paul Tarmonn, Energy Laboratories, Billings, MT

1:30 p.m. 1. *Interactions and Possible Protective Properties of Colloidal Hematite with Various Hydrazine Compounds*
Bowen, J. Sullivan, P. and Sullivan. B., Department of Chemistry, University of Wyoming, Laramie, WY

2:00 p.m. 2. *Geogenetic Water Quality of the New World Mining District, Park County, Montana*
Furniss, G., University of Montana, Missoula, MT

2:30 p.m. 3. *Surfactant-enhanced Electrokinetic Remediation of Hydrocarbon Contaminated Soils*
Bhattacharya, S., Reddy, M., Foster, D., Department of Civil and Architectural Engineering, University of Wyoming, Laramie, WY.

3:00 p.m. **BREAK** **Teton Mezzanine**

3:00 p.m. **Poster Set up** **Teton Room**

3:30 p.m. 4. *Tailings Mineralogy and Their Environmental Impact on the Groundwater in the Old Mining Zone of San Antonio-El Triunfo, Southern Baja California, Mexico*
Carrillo, A., Drever, J. I., Department of Geology, University of Wyoming, Laramie, WY

4:00 p.m. 5. *Assessing the Role of Microbial Iron Reduction in the Natural Attenuation of Organic Contaminants in a Former Manufactured Gas Plant Site*
Markwiese, J. T., Colberg, P. J. S., Department of Zoology and Physiology, University of Wyoming, Laramie, WY

4:30 p.m. 6. *Distribution of Trichloroethylene and Selected Aliphatic and Aromatic Hydrocarbons between "Weathered" and "Unweathered" Fuel Mixtures and Groundwater: Equilibrium and Kinetic Considerations*
Doucette, W. J., and Dupont, R. R., Utah Water Research Laboratory, Utah State University, Logan, UT

B. Conjunctive Management: Quantity/Quality Surface/Groundwater Field Management **Grand Room**

Moderator: Paul Gottler, O'Brien & Gere, Inc., Lakewood, CO

1:30 p.m. 1. *Equus Beds Groundwater Recharge Demonstration Project, South-Central Kansas*
Stous, D., Klein, L., Burns and McDonnell Engineering, Kansas City, KS, Blain, G., City of Wichita, KS

2:00 p.m. 2. *Groundwater Management of the Ogallala Formation —Consideration for Development and Future Use*
Gottler, P., Mason, J. M., Gabriel, W. J., O'Brien & Gere, Inc., Lakewood, CO

2:30 p.m. 3. *Monitoring Ephemeral Stream Flows from the Inyo and Coso Mountains into the Owens Dry Lake Basin, California*
Conway, C. J., Cochran, G., Water Resources Center, DRI, Reno, NV

3:00 p.m. **BREAK** **Teton Mezzanine**

3:00 p.m. **Poster Set up** **Teton Room**

3:30 p.m. 4. *Using Chemical Indicators to Quantify Groundwater Recharge to Streams*
Miller, S. A., Spokane County Public Works Department, Spokane, WA

4:00 p.m. 5. *A Multi-state, Multi-community Effort to Manage a Common Groundwater Resource*
Petrich, C. R., Ralston, D. R., University of Idaho, Moscow, Idaho

4:30 p.m. 6. *Nevada's Groundwater Management Is Science-Based, Bet on It.*
Katzer, T., Cordilleran Hydrology, Inc., Johnson, M., Brothers, K., Las Vegas Valley Water District, Las Vegas, NV

C. Microbial Bioavailability, Interactions, and Biobarriers **Timberline II**

Moderator: Alfred Cunningham, Center for Interfacial Microbial Process Engineering, Montana State University

1:30 p.m. 1. *Experimental Study on the Reduction of Saturated Hydraulic Conductivity Caused by Enhanced Boimass Growth*
Wu, J., Zhang, R.,, Yang, J., Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY

2:30 p.m. 2. *Meso-scale Ultramicrobacteria Experiments: Biobarrier Formation*
Hiebert, R., MSE, Inc., Butte, MT

3:00 p.m. **BREAK** **Teton Mezzanine**

3:00 p.m. **Poster Set up** **Teton Room**

3:30 p.m. 3. *Influence of Biofilm Accumulation on Porous Media Hydrodynamics*
Cunningham, Alfred B., Center for Interfacial Microbial Process Engineering, Montana State University, Bozeman, MT

4:00 p.m. 4. *Bioavailibility*
Sturman, Paul, Center for Biofilm Engineering, Montana State University, Bozeman, MT

4:30 p.m. 5. *Applications of the Biobarrier Technology*
Costerton, J. William, Center for Biofilm Engineering, Montana State University, Bozeman, MT

4:30 - 7:30 p.m. **Wine and Cheese Reception / Poster Session** **Teton Room**

Authors will be present during this session

1. *Possible Sorption Specificity of Organo-Clays*
   Dickey, M.and Carron, K., Department of Chemistry, University of Wyoming, Laramie, WY
2. *Chromatographic Detection of Organic Compounds Using Surface-Enhanced Raman Spectroscopy*
   Kennedy, B.and Carron, K. Department of Chemistry, University of Wyoming, Laramie, WY
3. *"Fingerprinting" of Petroleum Products Using GC/FID*
   Slentz, K.and Ristau, S., Energy Laboratories, Rapid City, SD
4. *Geochemical Modeling for Assessing Aqueous Selenium Speciation*
   Sharmasarkar, S., Vance, G. F., and Reddy, K. J., Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY
5. *Immobilization of Contaminants with In-Situ Calcite Precipitation*
   Van Proosdij, E. M. H., and Reddy, K. J., Wyoming Water Resources Center, University of Wyoming, Laramie, WY
6. *Analysis of Concentration Fluctuation in Heterogenous Aquifers*
   Yang, J., Zhang, R., and Wu, J., Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY
7. *Adsorption of Oxalate on Gamma-Aluminum Oxide*
   Herries, J. J. and Buttry, D. A., Department of Chemistry, University of Wyoming, Laramie, WY
8. *Laboratory Evaluation of Microbial Transformations of Coal Tar Constituents in Three Low Redox Aquifers*
   Bedessem, M. E., Markwiese, J. T., Swoboda-Colberg, N., Mickley, L. D., Colberg, P. J. S., Department of Civil and Architectural Engineering, Department of Zoology and Physiology, University of Wyoming, Laramie, WY
9. *Chemical and Biological Transformations of Quadricyclane and Tricyclo[2.21.$0^{2,6}$]heptan-3-ol*
   Jin, S., Swoboda-Colberg, N., and Colberg, P. J. S., Department of Zoology and Physiology, University of Wyoming, Laramie, WY
10. *Assessment of Ground-Water Sensitivity and Vulnerability – Goshen County, Wyoming*
    Hamerlinck, J., and Arneson, C. S., Wyoming Water Resources Center, University of Wyoming, Laramie, WY
11. *Distribution Coefficient (K_d) Values for the Partitioning of Cu between Wyoming Soils and Pore Waters: Initial Results*
    Stillings, L. L., Sullivan, A. B., and Drever, J. I., Department of Geology and Geophysics, University of Wyoming, Laramie, WY
12. *Controls on the Distribution of Copper in Surface Waters Associated with the Ferris-Haggerty Mine, Carbon County, Wyoming*
    Bell, A. A., Drever, J. I., Department of Geology, University of Wyoming, Laramie, WY
13. *Investigation of Microbial Communities Responsible for Degradation of Toluene in Exposed and Unexposed Soils*
    Shockley, D. L., Meyer, J. S., and Colberg, P. J. S., University of Wyoming, Laramie, Wyoming

Thursday, October 5, 1995

8:00 a.m. **Continental Breakfast** **Teton Mezzanine**

8:30 - 11:30 a.m. **Concurrent Sessions A & B**

A. Mathematical Modeling **Teton Room**

Moderator: Myron Allen, Department of Mathematics, University of Wyoming

8:30 a.m. 1. *Fractured Aquifer Groundwater Flow Simulation*
Wang, Z., and Niss, C., TriHydro Corporation, Laramie, WY

9:00 a.m. 2. *Beyond Hydraulic Heads: Use of Additional Data in Groundwater Inverse Modeling*
Hill, M., U.S. Geological Survey, Lakewood, CO

9:30 a.m. 3. *Scaling Issues in the Numerical Simulation of Advection-dominated Transport in Porous Media*
Allen, M. B., Furtado, F., Department of Mathematics, University of Wyoming, University of Campinas, Brazil

10:00 a.m. **BREAK** **Teton Mezzanine**

10:30 a.m. 4. *Visualization Techniques for Use with Mathematical Groundwater Models*
O'Leary, Patrick, University of Wyoming, Laramie, WY

B. Conjunctive Management: Management Through Regulatory Methods **Grand Room**

Moderator: John Arrigo, Montana Department of Environmental Quality

8:30 a.m. 1. *Helena Valley Aquifer Groundwater Nitrate Concentration Trends*
Drake, V., Lewis and Clark County Water Quality Protection District, Helena, MT

9:00 a.m. 2. *Implementation of Montana's Water Quality Nondegradation Policy*
Arrigo, J., Montana Department of Environmental Quality, Helena, MT

9:30 a.m. 3. *An Innovative Approach to Local Water Quality Protection*
Nielsen, P., Missoula Valley Water Quality District, Missoula, MT

10:00 a.m. **BREAK** **Teton Mezzanine**

10:30 a.m. 4. *The Groundwater Vulnerability Assessment Bandwagon: Sorting Out Use and Abuse, Science and Uncertainty*
Hamerlinck, J. D., Wyoming Water Resources Center, University of Wyoming, Laramie, WY

11:00 a.m. 5. *Overview of Wyoming Wellhead Protection Program*
Jarvis, T., Allen, R., Weston Engineering, Inc., Laramie, WY and Frederick, K., Wyoming DEQ

11:30 - 1:30 p.m. **Lunch on your own**

1:30 - 5:00 p.m. **Concurrent Sessions C, D, & E**

C. MONITORING TECHNOLOGIES **TETON ROOM**

Moderator: Roger Noble, Montana Department of Natural Resources and Conservation

1:30 p.m. 1. *ChemSensor and AccuSensor: Field Instrumentation for On-site Analysis of Common Contaminants*
Henshaw, J., Cockwell, R., ORS Environmental Systems, Englewood, CO and Greenville, NH

2:00 p.m. 2. *Hydrogeology and Assessment of TCE Contamination in the Southern Portion of the Pocatello Aquifer*
Noble, R., Montana Department of Natural Resources and Conservation, Kalispell, MT

2:30 p.m. 3. *The Pros and Cons of Direct Push Mini-Wells*
Gottler, P., O'Brien & Gere Engineers, Lakewood, CO

3:00 p.m. **BREAK** **Teton Mezzanine**

3:30 p.m. 4. *Environmental Monitoring Using Raman Spectroscopy*
Carron, K. Department of Chemistry, University of Wyoming, Laramie, WY

D. OPTIONS FOR REGULATORY AND CLEANUP POLICY **Grand Room**

Moderator: Todd Jarvis, Weston Engineering, Inc., Laramie, WY

1:30 p.m. 1. *Risk-Based Corrective Action (RBCA) Cleanup Criteria for Petroleum Sites in South Dakota*
Slentz, K., Energy Laboratories, Rapid City, SD

2:00 p.m. 2. *The Missoula Valley Aquifer Protection Ordinance*
Cerquone, C., Missoula City-County Health Department, Missoula, MT

2:30 p.m. 3. *Determination of Site-Specific Soil and Groundwater Cleanup Levels Using a Health-based Risk Assessment Approach*
Wang, Z., Richter, H., Hardy, J., Niss, C., TriHydro Corporation, Laramie, WY

3:00 p.m. **BREAK** **Teton Mezzanine**

3:30 p.m. 4. *Obtaining Alternate Cleanup Levels for Chlorinated Solvents in Groundwater*
Olsen, R. L., Nolen, C. H., Camp Dresser & McKee, Inc., Denver, CO

4:00 p.m. 5. *Science Meets Policy: DNAPL Contamination in Laramie, Wyoming and the Technical Impracticability Waiver*
Jarvis, T., Weston Engineering, Inc., Kincaid, T., University of Wyoming, Colby, H., City of Laramie, Laramie, WY

E. State Engineer's Office Meeting for Groundwater Managers: Update on State Groundwater Management Activities **Timberline I**

1:30 - 5:00 p.m. The Wyoming State Engineer's Office, Groundwater Section is sponsoring a meeting with members of groundwater programs from the other Rocky Mountain states. The purpose of this meeting is to provide representatives an opportunity to share information and knowledge regarding major issues and concerns confronting state groundwater management programs. Each state will be given approximately one half hour to present and discuss the status, progress, successes, and problems encountered as they work toward their mutual goal of developing and implementing effective and efficient groundwater management programs. All those interested in hearing perspectives on state management issues are invited to attend.

Session Chairman: Richard G. Stockdale, Wyoming State Engineer's Office

Speakers:

- Herb Dishlip, Department of Water Resources, AZ
- Ron Carlson, Department of Water Resources, ID
- Glenn Graham, Division of Water Rights, CO
- Jerry Olds, Department of Natural Resources, UT
- Tom Patton, Department of Natural Resources, MT
- Ray Murphy, Wyoming State Engineer's Office, WY

6:00 & 6:15 p.m. Buses depart from in front of Snow King for the National Wildlife Art Museum

6:30 - 8:30 p.m. **National Wildlife Art Museum Tour and Reception**

Friday, October 6, 1995

8:00 a.m. **Continental Breakfast** **Teton Mezzanine**

8:30 - 11:00 p.m. **Conference Wrap-up and Moderated Panel Discussion** **Grand Room**

So, Who Really Is Driving Groundwater Management?

Moderator: Dorothy Bradley, Director, Montana Water Resources Center, Montana State University, Bozeman, Montana

Panelists:

- Vivian Baker, Lewis and Clark County Water Quality Protection District, Helena, Montana
- J. William Costerton, Center for Biofilm Engineering, Montana State University, Bozeman, Montana
- Bill Brown, President, Energy Laboratories, Billings, Montana

11:00 a.m. **Closing Remarks**
Steven P. Gloss, Director, Wyoming Water Resources Center, University of Wyoming, Laramie, WY

Paper Abstracts

(Abstracts arranged in alphabetical order according to the name of the first author.)

Scaling Issues in the Numerical Simulation of Advection-Dominated Transport in Porous Media

Allen, M. B., III
University of Wyoming

Furtado, F.
University of Campinas
Campinas, Brazil

ABSTRACT

Advection-dominated transport in porous media occurs in several practical settings, including groundwater cleanup and enhanced oil recovery. The upscaling problem arises because natural porous media are spatially heterogeneous, and scales at which we measure medium properties usually differ from scales at which we intend to model transport. Classically, the upscaling problem consists of determining "effective" medium properties that preserve the form of the governing equations but more accurately represent the physics at scales of interest. Subtle problems occur when upscaling involves a change in the form of the governing equations. We discuss computational methods for attacking these problems.

Implementation of Montana's Water Quality Nondegradation Policy

Arrigo, J.L.
Montana Department of Environmental Quality

ABSTRACT

Montana has recently taken unique steps in the development and implementation of its water quality nondegradation policy. The Montana Water Quality Act nondegradation policy was originally enacted in 1972; however, implementation of the policy was weak because of the lack of guidance on what actually constituted degradation. Amendments to the policy that were passed in 1993 provided a definition of degradation, created criteria for the establishment of mixing zones, and developed the concept of "nonsignificant" changes in water quality that do not constitute degradation. Degradation of high-quality water is prohibited unless it is demonstrated that the change in water quality is necessary because: a) there are no feasible alternatives to the proposed project; b) the project will result in important economic or social development; c) water uses will be protected; and d) the least degrading water quality protection practices will be implemented. Regulations that were adopted in 1994 to implement the new policy include criteria used to quantify nonsignificant changes in water quality. The regulations also list categories of activities that are assumed to create nonsignificant changes. The desire to expand precious metal mining and increased subdivision development with onsite sewage disposal systems have tested the workability of these regulations. Development advocates contend that the nonsignificant criteria are too stringent, while environmental interests take the opposite position. The 1995 Legislature sided with the resource developers and loosened the nonsignificant criteria and corresponding water quality standards, particularly for arsenic and nitrates.

Surfactant-Enhanced Electrokinetic Remediation of Hydrocarbon Contaminated Soils

Bhattacharya, S., Reddy, M., and Foster, D.
University of Wyoming

ABSTRACT

The objective of the research discussed in this paper was to evaluate the effect of electrokinetics and surfactant and the combination of the two in removing residual gasoline from soil. Two types of soil were used in this experiment. One was pure kaolinite and the other was field-soil obtained from a contaminated site in Laramie, Wyoming. Experiments were performed in a set of glass columns fitted with graphite electrodes at top and bottom. In each column, the top electrode was used as the anode while the bottom one was used as the cathode. Flow took place from top to bottom by the coupled gradients of electrical and hydraulic potentials. The kaolinite was artificially contaminated by (1) injecting 10 ml. gasoline into the column and (2) mixing 10 ml. gasoline thoroughly with the wet kaolinite before compacting it into the column. The field soil was contaminated at least six years ago by an incident of underground storage tank leak at a gas station in Laramie, Wyoming. For the field soil, the initial concentration of gasoline (mg/kg) was determined before subjecting it to any treatment. There was one replicate and one control column for each type of soil used. Each of the two soils was first characterized to determine its soluble cation concentrations, organic content, particle size, bulk density, and hydraulic and electroosmotic conductivities. The columns were first subjected to flushing with up-flowing distilled water and as much gasoline as possible was removed. The aqueous gasoline samples were collected from the top outlet of the column and each sample was analyzed by gas chromatography. The portion remaining in the column after flushing was considered to be the residual gasoline. Next, electrical potential gradient was applied by a D. C. power supply together with the same hydraulic gradient that was used for flushing. Samples were collected from the bottom outlet of the column and subjected to gas chromatographic analysis. As a result of applying electrical power the effluent concentration increased initially, but gradually declined as more and more pore volumes of water passed through the column. Then a 0.25% solution of sodium dodecyl sulphate was passed through the columns with the same hydraulic gradient. This again caused an increase in the concentration of gasoline in the effluent but tended to tail off. Next, the column was subjected to combined application of electricity and surfactant. This last stage seemed to produce maximum recovery. A significant fraction of surfactant was found to be adsorbed by the field soil. There was a pH gradient along the length of the column which results due to electrolysis of pore water. In this paper, details of the experiments, results, and implications for practical application will be described.

Interactions and Possible Protective Properties of Colloidial Hematite with Various Hydrazine Compounds

Bowen, J.M., Sullivan, B.P., Sullivan, B.A.
Dept. of Chemistry and Pharmacy
University of Wyoming

ABSTRACT

Hydrazines are potential contaminants in the ground and groundwater from use as fuel components. In an effort to characterize the fate and transport of these compounds, the interactions of these compounds with a naturally occurring soil constituent hematite, an aqueous colloidial iron oxide, are studied. The study included determining the degradation of the hydrazines by auto-oxidation in the presence of hematite by sorption isotherm techniques and directly with the use of attenuated total reflectance infrared spectroscopy (ATR-FTIR). It was observed from the solution experiments that the auto-oxidation of hydrazine was negligible in low pH environments, but considerable at high pH situations. When compared with the rate of auto-oxidation of hydrazine in water, it was found that in the presence of colloidial hematite, the auto-oxidation of hydrazine was substantially attenuated apparently due to an adsorption interaction. ATR-FTIR was used to directly characterize the mechanism of this interaction between hydrazine and hematite.

Funded by the Environics Directorate of the U.S. Air Force, Tyndall AFB, FL, through Applied Research Associates.

Tailings Mineralogy and Their Environmental Impact on the Groundwater in the Old Mining Zone of San Antonio-El Triunfo, Southern Baja California, Mexico

Carrillo, A. and Drever, J.I.
Department of Geology and Geophysics
University of Wyoming

ABSTRACT

The San Antonio-El Triunfo area was the site of major gold and silver mining during the last century. Old tailings are a potential source of contamination for a major regional aquifer. Some wells already show elevated As concentrations (>0.05 mg/l). Twenty samples of tailings have been analyzed by X-ray diffraction and scanning electron microscope/energy dispersive X-ray spectrometry (EDS). Arsenolite (As_2O_3) is present in at least four of the samples; arsenic, iron, zinc and sulfur were identified by EDS in most of the samples. Zn, Pb, Cu, Ni, Sn, Sb, and V were also present in significant concentrations. Humidity cells were used to simulate the alteration of the tailings in the vadose zone, particularly reactions that generate and consume acidity. Preliminary results show As concentrations between 1 and 300 ppm, and SO_4 concentrations between 50 and 700 ppm in the leachates; the concentration of other elements were only in the ppb range. The pH of the leachates ranged between 3 and 8.

Environmental Monitoring Using Raman Spectroscopy

Carron, K.
Department of Chemistry
University of Wyoming

ABSTRACT

Environmental monitoring can be challenging due to the complex matrices present with the sample. We are developing surface science methods to target specific contaminants through adsorption. This removes many of the interferences that can occur in common spectroscopies. Further, measurement integrity is attained through the use of a vibrational spectroscopy, Raman Scattering. Raman is a fingerprint technique and can distinguish between structurally similar compounds. Normal Raman spectroscopy is difficult due to its lack of sensitivity and potential interference from fluorescence. We have circumvented these difficulties with the use of Surface Enhanced Raman Scattering (SERS) spectroscopy that enhances the signal at special metal surfaces by as much as 10 million and is capable of quenching fluorescence. Results for the monitoring of BTEX and chlorinated ethylenes will be presented.

The Missoula Valley Aquifer Protection Ordinance

Cerquone, C.

Missoula City-County Health Department
Missoula Valley Water Quality District

ABSTRACT

The Missoula sole source aquifer is under increasing demand and is extremely vulnerable to pollution. To protect the aquifer, the Water Quality District has embarked on a unique local regulatory program. An instrumental component of the program is the Missoula Valley Aquifer Protection Ordinance. Passed unanimously by local elected officials, the Ordinance places institutional controls on new and existing businesses, enacts stricter requirements for new and existing fueling facilities, bans the sale of perchloroethylene, creates a permitting program, grants enforcement powers to the District to cleanup contamination, and adopts siting requirements for new public water supply wells. The Ordinance is an example of a regulatory policy adopted by Missoula residents in an attempt to provide long-term protection of the aquifer. Interest in the Ordinance from communities throughout Montana and the Northwest has surfaced as they attempt to secure clean water.

Monitoring Ephemeral Stream Flows from the Inyo and Coso Mountains into the Owens Dry Lake Basin, California

Conway, C.J. and Cochran, G.
Water Resources Center
Desert Research Institute (DRI)
Reno, NV 89506

ABSTRACT

Groundwater from the Owens Dry Lake basin is currently being considered for dust mitigation purposes. DRI is conducting research at Owens Dry Lake to define components of the water budget such as perennial and ephemeral stream flows, evapotranspiration, and groundwater inflow. A numerical model of the lake basin groundwater flow system will be developed to help determine where groundwater can potentially be developed without undesired environmental impacts. A portion of the groundwater recharge component is derived from transmission losses along ephemeral flow stream channels at the base of the Inyo and Coso Mountains. Hydrologic monitoring of ephemeral stream flows with pressure transducers in PVC enclosures has been accomplished within selected watersheds. Modifications have been required to obtain successful discharge hydrographs in this extreme environment. Discharge hydrographs were developed and the hydrologic modelling program HEC-1 will be used for estimation of stream channel losses and east/southeast-side recharge.

Applications of the Biobarrier Technology

Costerton, J. W.
Center for Biofilm Engineering
Montana State University

ABSTRACT

We have developed a novel biotechnology that uses ultramicrobacteria (UMB) to penetrate porous media and nutrients to stimulate their growth to produce an effective biobarrier. UMB are prepared from nonpathogenic environmental strains of bacteria, by prolonged starvation, and these very small ($\pm$O.3μm) cells are able to penetrate sand and most soils very readily. The addition of nutrients, which are used as a "chaser", causes these UMB to resuscitate, replicate, and produce extracellular polysaccharide slime until the pore spaces of the porous media are virtually filled with viscous biomass. These biobarriers have been tested very extensively at the mesoscale level and they are under consideration for use in plugging the most permeable parts of oil bearing formations to prevent water breakthrough during waterflooding operations. If these barriers were placed in the shallow subsurface, our data indicate that they would block water flow, and our data have also established that these biobarriers are not damaged by heavy metals (Ce,Sr) or by organic solvents (Charbon tetra chloride). Modifications of these biobarriers can be used to step oxygen penetration into pyrite containing mine tailings and thus to present acid mine drainage.

Influence of Biofilm Accumulation on Porous Media Hydrodynamics

Cunningham, A.B.
Center for Interfacial Microbial Process Engineering
Montana State University
Bozeman, Montana 59717

ABSTRACT

Laboratory scale porous media biofilm reactors were used to evaluate the effect of biofilm accumulation, measured as the average thickness along a 50 mm flow path, on media porosity, permeability, and friction factor. Media tested consisted of 1 mm glass spheres, 0.70 mm sand, 0.54 mm sand, and 0.12 mm glass and sand. *Pseudomonas aeruginosa* was used as inoculum and 25 mg l^{-1} glucose substrate was continuously supplied to the reactor. Reactors were operated under constant piezometric head conditions resulting in a flow rate decrease as biofilm developed. The progression of biofilm thickness followed a sigmoidal shaped curve reaching a maximum thickness after about 5 days. Media porosity decreased between 50 and 96% with increased biofilm accumulation while permeability decreased between 92 and 98%. Porous media friction factor increased substantially for all media tested. Observations of permeability in the biofilm-media matrix indicate that a minimum permeability (3 to 7 x $10^{-8}cm^2$) persisted after biofilm thickness has reached a maximum value. Such results indicate substantial interaction between mass transport, hydrodynamics and biofilm accumulation at the fluid/biofilm interface in porous media. Improved understanding of these interactions will lead to industrial and environmental application in enhanced oil recovery, and bioremediation of contaminated groundwater and soil.

Distribution of Trichloroethylene and Selected Aliphatic and Aromatic Hydrocarbons between "Weathered" and "Unweathered" Fuel Mixtures and Groundwater: Equilibrium and Kinetic Considerations

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ABSTRACT

The distribution of trichloroethylene and several aliphatic and aromatic fuel components between "weathered" and "unweathered" fuel mixtures and groundwater was investigated using a "slow stirring" method. The "weathered" fuel mixtures were obtained from several contaminated field sites. Both unlabeled and 14C-labeled test compounds were used in the distribution experiments. Analysis of the test compound concentrations over time was performed by gas chromatograph or liquid scintillation counting. The time required to reach equilibrium varied from about 24 to 72 hours. Generally, the greater the hydrophobicity of the test compounds the longer time that was required to reach equilibrium. It was also observed that the fuel/water distribution coefficients were generally larger for the "weathered' fuels than those measured for the "unweathered" fuels, in some cases by a factor of 100. The "weathered" fuel mixtures obtained from the field site were depleted of the more water soluble compounds over time and became significantly more enriched in long chain aliphatic hydrocarbons. The ability of several models to describe the observed distribution behavior was examined.

Helena Valley (Montana) Aquifer Groundwater Nitrate Concentration Trends

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ABSTRACT

The investigation was undertaken to determine if Helena Valley aquifer nitrate concentrations are changing over time and to determine if they exhibit trends which correlate with population growth and aquifer utilization in the Helena area.

Although Helena Valley aquifer water quality remains good, basic statistical comparisons of nitrate concentration data taken in 1990 and 1994 showed a 2.5 percent increase in the mean value.

Permitted septic system installations increased by 26 percent throughout the study area from 1990 through 1994. Positive correlation between septic system density and groundwater nitrate concentration is evident from comparison of modeled nitrate isopleths with septic system density maps. Groundwater exhibiting nitrate concentrations to a level above one mg/l increased from 49 to 58 square miles, representing a 19 percent increase in four years. Highest nitrate concentrations coincide with areas having the highest septic system densities, and with the large cemeteries located in the Helena Valley.

Geogenetic Water Quality of the New World Mining District, Park County, Montana

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ABSTRACT

Natural acid drainage from oxidation of sulfide minerals occurs at the headwaters area, New World mining district, northeast of Yellowstone Park. Pleistocene glaciers eroded sulfide-bearing rocks distributing acid-generating minerals in local till. Sporadic mass wasting of high elevation terrain exposes sulfide minerals to weathering. Iron oxide and heavy metals deposited in headwater stream sediments, from prehistoric acid drainage left datable geologic records in massive stream terraces. Plant debris cemented into stratified iron oxide allows radiometric dating. Depositional ages of 8270 +/- 70 years BP near the bottom, and 5810 +/- 80 years BP near the top of the terraces bracket intermediate dates. Analysis of ancient terrace and recent stream iron oxide cements show nearly identical chemistry. Natural acid springs, abundant sulfides, and oxidation products occur in headwater areas, undisturbed by historic mining. The research shows the area streams have been impacted by naturally occurring acid drainage and heavy metals for thousands of years.

Ground Water Management of the Ogallala Formation - Consideration for Development and Future Use

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O'Brien & Gere, Inc.
Lakewood, Colorado

Mason, John M.
O'Brien & Gere, Inc.
Syracuse, NY

Gabriel, William J.
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ABSTRACT

The Ogallala Formation is the main stratigraphic unit of the High Plains Aquifer, and is recognized as one of the most prolific fresh water aquifers in the United States. To effectively manage this ground water resource, an understanding of the geology and hydrogeology of the Ogallala Formation is essential. This study focuses on the geologic characteristics of the Ogallala Formation and the hydrogeologic properties of the aquifer in the type locality of Ogallala, Nebraska. The results of the study identified an upper and lower aquifer zone separated by an aquitard. The upper aquifer zone was found to be adequate for industrial and agricultural uses, whereas the lower aquifer zone was of suitable quality for use as a potable water source. Care should be given when utilizing or developing this resource to limit the migration and/or mixing of water from the upper to the lower aquifer zone.

The Pros and Cons of Direct Push Mini-Wells

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ABSTRACT

With the increased use and acceptance of mini-wells installed by direct push methods to identify groundwater contamination comes information supporting and refuting the technology. This new method for extracting groundwater is being used throughout the industry to reduce investigatory costs. The advantages of direct push mini-well installation include the lack, thus far, of permitting requirements, the low visibility with respect to full size drill rigs, the lower overall costs, and the ability to access difficult locations. The detractions include data reliability, the inability to provide adequate hydrogeologic information, and the constraints on installation with respect to bedrock, areas with caliche or boulders, and clay-rich soils. Information retrieved from western slope sites have allowed a comparison of information and costs associated with mini-wells and wells installed using hollow stem auger methods.

The Groundwater Vulnerability Assessment Bandwagon: Sorting Out Use and Abuse, Science and Uncertainty

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ABSTRACT

In response to the increased awareness of the need for effective and efficient proactive methods for protecting ground-water resources from future contamination, scientists and resource managers have been developing techniques which focus on predicting relative contamination potential resulting from activities at or near the land surface. Since the introduction of DRASTIC more than ten years ago, such methods for assessing the potential for aquifer contamination have been met with as much criticism as praise. Yet today, with the growing availability of such supporting technology as geographic information systems, these assessment tools are being broadly employed across the continent in a wide range of situations and scales. Consequently, with such widespread application, potential misuse arises. This paper will review the strengths and weaknesses of vulnerability assessment tools in terms of their benefits and limitations for groundwater protection policy development and resource management. Examples of pitfalls, as well as potential solutions, will be presented from both existing literature and from research currently underway at the University of Wyoming's Water Resources Center.

ChemSensor[R] and AccuSensor[TM]: Field Instrumentation for On-Site Analysis of Common Contaminants

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Cockwell, R.
ORS Environmental Systems
Englewood, Colorado

ABSTRACT

ORS Environmental Systems has developed two new technologies for performing on-site analysis of common contaminants. These products are a result of the need for real time information at a site during investigation, assessment remediation or closure phases.

The ChemSensor[R] uses fiber optic technology to enable the determination of BTEX in water contaminated by petroleum products. The response of ChemSensor[R] is correlated to a laboratory analysis for a site. This approach has been approved by Region I of New York State as a means to reduce laboratory analytical costs.

The AccuSensor[TM] provides a quantitative determination of TCE in water with sensitivity down to 5 ppb. This sensor uses an analytical reagent which will react with TCE in a sample to form a light-absorbing product that is probed colorimetrically. The concentration of TCE in the sample is then displayed after a five minute reaction period.

Meso-scale Ultramicrobacteria Experiments: Biobarrier Formation

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ABSTRACT

The purpose of the Ultramicrobacteria Biobarrier Project is to show that barriers formed using ultramicrobacteria (UMB) can prevent flow of contaminated or uncontaminated water through porous media. Two experimental configurations have been used. Pilot-scale tests consisted of passing UMB and nutrient through porous media in small cylindrical test chambers. The chambers were placed under constant hydraulic pressure and the flow rate through them was reduced by more than 95%. Contaminants were added to the constant head tank and placed in contact with the biobarrier for at least two months. The barrier was unaffected by the presence of aqueous solutions of strontium, cesium, and carbon tetrachloride.

Larger meso-scale test chambers were designed in an attempt to model an actual biological barrier in the field. UMB and nutrient were injected independent of the movement of simulated groundwater. Following barrier formation, flow rate reductions greater than 99.99% were achieved. A short pulse of nutrient every few weeks was necessary to maintain barrier integrity.

Additional contaminant challenge tests and biobarrier optimization are a few of the experiments planned for future work. This work is being conducted through the Department of Energy - Environmental Management Office of Technology Development at the Western Environmental Technology Office under DOE Contract Number DE-AC22-88ID12735.

Beyond Hydraulic Heads: Use of Additional Data in Groundwater Inverse Modeling

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ABSTRACT

A crucial issue in the simulation of groundwater systems is what types of data are likely to produce accurate predictions. In this paper, this question is addressed using nonlinear regression inverse techniques and associated statistics; the data discussed are limited to measures of subsurface flow and transport dynamics. Specific questions addressed are: 1) How accurately can a model be calibrated with only hydraulic head data, which are commonly the only data on subsurface flow dynamics used to judge model accuracy? 2) How much would additional potentially available data be likely to improve model accuracy? Two synthetic examples and two field examples are used to demonstrate nonlinear regression inverse methods and their associated statistics. Additional data types considered include: 1) flows at groundwater/surface water boundaries, 2) adjective travel times and paths inferred from concentration data, and 3) concentration data used directly in the regression. Results indicated that use of head data alone often resulted in extremely correlated parameters, was insufficient to distinguish between accurately and inaccurately designed models, and produced unreasonable parameter estimates even for accurate models. Including additional types of data enabled the identification of model inaccuracies and consistently produced reasonable parameter values for accurately designed models.

Overview of Wyoming Wellhead Protection Program

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ABSTRACT

In 1986, Amendments to the Safe Drinking Water Act (SDWA) established the Wellhead Protection (WHP) program. Under these Amendments, each state is called upon to develop a program that would protect groundwater which supplies wells, well fields, springs, and tunnels that provide drinking water to the general public. The principal objective of this program is to prevent the contamination of groundwater resources that supply public drinking water. In Wyoming, the development and administration of the WHP program is the responsibility of the Department of Environmental Quality, Water Quality Division. The development of the state's program stems from the appointment of a 20 member, multi-disciplinary advisory committee to assist with identification of goals, guidelines, minimum criteria and other needs deemed pertinent by the committee. The basic premise behind the state's program is to promote voluntary participation, and provide guidance on how to "do-it -yourself" at the local level.

Science Meets Policy: DNAPL Contamination in Laramie, Wyoming and the Technical Impracticability Waiver

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Kincaid, T.
University of Wyoming

Colby, H.
City of Laramie

ABSTRACT

Restoration of contaminated groundwater is one of the primary objectives of both the Superfund and RCRA Corrective Action programs. While both programs have had good success in reducing immediate threats posed by contaminated groundwater, experience over the past decade has shown that restoration to drinking water standards may not be achievable due to limitations in available remediation technologies and hyrogeologic factors. EPA has recognized the impracticability of attaining clean-up levels in some hydrogeologic settings, and has developed guidance for evaluating the applicability of a Technical Impracticability Waiver. While the Wyoming Department of Environmental Quality has no formal regulations which parallel the EPA Technical Impracticability Waiver, it recently has approved "No further action at this time" status for a DNAPL-contaminated karst aquifer in Laramie, Wyoming using the Technical Impracticability Waiver philosophy. This case study also describes the genesis of the previously unrecognized karst landscape within the City of Laramie.

Nevada's Groundwater Management is Science Based, Bet On It.

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ABSTRACT

Nevada, the driest state in the Union, initiated groundwater law in 1879 by providing a bounty for drilling artesian wells. Clearly, times have changed and so has the law over the last 116 years as groundwater hydrology developed as a science. In 1960, the State began to define basin water budgets of nearly 250 groundwater basins in the State and these budgets are used by the State to allocate and manage the public waters; 50 basins are highly regulated.

The technique for estimating recharge is based on the empirical derived relationship between precipitation and groundwater recharge. A recent evaluation of this technique shows it fairly reliable. The groundwater discharge from the basins also requires estimation, but has certainty of actual springflow measurements in many valleys coupled with uncertainty of estimating discharge by phreatophytes.

Assessing the Role of Microbial Iron Reduction in the Natural Attenuation of Organic Contaminants in a Former Manufactured Gas Plant Site

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ABSTRACT

Field and laboratory investigations conducted at a former manufactured gas plant (MGP) site suggest that microbially mediated iron(III) reduction may be an important process in the natural attenuation of coal tar derived hydrocarbons. Concentrations of reduced iron [Fe(II)] in the ground water average 500 mg/L, oxygen is limited (0-2 mg/L) and nitrate is absent. Calculations using field data indicate that there is a strong linear correlation between carbon dioxide and dissolved iron in the aquifer, suggesting that Fe(III)-reducing microorganisms may be coupling the oxidation of organic contaminants to the reduction of Fe(III) at the site. Iron-reducing bacteria have been shown to exist throughout the aquifer to a depth of 30 m. Work is currently in progress to assess whether or not Fe(III)-reducing enrichment cultures obtained from the aquifer are able to transform organic contaminants like benzene and naphthalene.

Using Chemical Indicators to Quantify Ground Water Recharge to Streams

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ABSTRACT

Water quality parameters were used to estimate the quantity of ground water recharge to two streams in Spokane County, Washington. The two streams, the Spokane River with an annual average flow of about 170 m^3/sec (6000 ft^3/sec) and Dragoon Creek with an annual flow of 0.6 m^3/sec (21 ft^3/sec) represent the range of flows typical in the area.

Calcium concentrations in the Spokane River and the hydraulically connected Spokane Valley Aquifer indicate that as much as 95% of summer low flow in the river were derived from the aquifer during the summer. Proportionally lower percentages of ground water were indicated as river flow increased. The values calculated using chemical considerations support the results of computer modeling.

Based on nitrate-nitrogen concentrations, ground water recharge to the lower reaches of Dragoon Creek provides at least 10% of the stream's flow.

The Missoula Valley Water Quality District - An Innovative Approach to Local Water Quality Protection

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Missoula Valley Water Quality District

ABSTRACT

The Missoula Valley Water Quality District was created by the Missoula Board of County Commissioners and Missoula City Council in 1993, as authorized by legislation adopted by the 1991 Montana Legislature. The mission of the water quality district is to protect the quality of surface and groundwater within the 208 square mile Missoula Valley, in western Montana. The primary focus of the district is protection of the Missoula Valley Sole Source Aquifer.

Creation of the District has allowed local government to assume more direct control over the quality of water in the valley. The District is funded by a fee assessed on all improved properties and mobile homes within the boundaries of the district, which ensures a stable and long-term source of funding for the local program.

The Water Quality District's program includes:

1. Monitoring and research

2. Integrated inspections of facilities regulated under local, federal and state laws

3. Adoption and enforcement of local aquifer protection regulations, and delegated enforcement of Montana Water Quality Act

4. Public Education

5. Local review of state and federal cleanup sites, and in some cases local assumption of lead enforcement authority

6. Annual household hazardous waste collection events

7. Installation of a dedicated, long-term ambient groundwater monitoring well network

Hydrogeology and Assessment of TCE Contamination in the Southern Portion of the Pocatello Aquifer: A Case Study*

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ABSTRACT

The City of Pocatello, Idaho relies exclusively on a valley-fill aquifer to supply all of the domestic and industrial water needs. In 1993, water service was supplied by 20 municipal wells to meet an annual demand of 5.75 billion gallons. The detection of a number of volatile organic contaminants, the most pervasive and significant of which is trichloroethylene (TCE), resulted in the closure of four municipal wells located in the southern wellfield. This contaminant is migrating at a rapid rate (3.4 to 16.2 ft/day) and threatens other downgradient wells. Analytical results from 85 wells sampled in the study area indicated TCE concentrations ranged from zero to 31.7μg/L. Depth-integrated sampling results show the TCE plume exists in a dissolved aqueous-phase and is vertically dispersed throughout the saturated thickness of the aquifer; however, there is a well-defined lateral concentration gradient. This type of plume configuration implies that transverse dispersivity is nominal and that advection is the predominant process controlling TCE mass transport. It is therefore concluded that rapid groundwater flow has resulted in a highly dispersed TCE plume in vertical profile with minimal lateral dispersion.

As an interim solution to this problem, the City intends to install two capture wells to control contaminant migration. Optimum well locations were determined by using the computer flow model MODFLOW. Groundwater pumped from the extraction wells will be treated using conventional air-stripping techniques. The wells and air-stripper towers have a design treatment capacity of 2,250 gpm each. The treated water will then be pumped into the City's distribution system for potable use.

*This work was conducted while the author was employed by CH2M Hill, Boise, Idaho.

Visualization Techniques for use with Mathematical Groundwater Models

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ABSTRACT

Mathematical modeling has evolved into a third research technique along side the more traditional theoretical and experimental methods. The increased use of mathematical models, coupled with the increased throughput of the modern computer, has created a problem in the analysis and dissemination of computed results. Visualization techniques not only can enhance understanding through the post processing of computed data, but also can play a role in monitoring and steering ongoing simulations. Case studies demonstrate the benefits of scientific visualization. Further benefits can result from the simultaneous development of groundwater models with visualization techniques.

A Multi-State, Multi-Community Effort to Manage a Common Groundwater Resource

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ABSTRACT

Groundwater management in a region spanning a state border poses a unique challenge. Aquifers in the Pullman-Moscow basin in Washington and Idaho represent the only practical water supply for two communities and two state universities. Declining groundwater levels prompted state concern, which led to the formation of a unique, multi-jurisdictional committee consisting of representatives from two cities, two counties, and two universities. The committee was charged with developing and implementing a local groundwater management plan aimed at reducing the rate of pumpage increases. The committee developed an internal taxing structure to support scientific studies of the basin. The committee is also developing and implementing policies to stabilize local pumping rates. Efforts to reduce the rate of pumping increases in a growing community serve as an example of science and policy driving groundwater management.

Obtaining Alternate Cleanup Levels for Chlorinated Solvents in Groundwater

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ABSTRACT

Evaluation of the data collected during the Remedial Investigation/Feasibility Study at the Gilbert-Mosely Site in Wichita, Kansas revealed that contamination of the alluvial groundwater aquifer above MCLs was extensive, covering 1,800 acres and containing over 2.75 billion gallons of water contaminated with trichloroethane, tetrachloroethane, and vinyl chloride. Based on technical impracticability of aquifer restoration and risk-based calculations, CDM and the City proposed an alternate cleanup level (ACL versus MCLs). The Kansas Department of Health and the Environment and the U.S. EPA issued a Corrective Action Decision, selecting groundwater containment at an ACL, in combination with institutional controls and monitoring. This resulted in a 60 percent reduction in the area and volume of groundwater that required cleanup/containment, and translated into several million dollars of remediation cost savings.

Risk Based Corrective Action (RBCA) Cleanup Criteria for Petroleum Sites in South Dakota

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ABSTRACT

Cleanup criteria, based upon the impacts to human health and environmental resources, are currently receiving much attention nationwide for sites contaminated with regulated substances. In the State of South Dakota, rules are being developed to assess and remediate petroleum contaminated sites using risk based standards. These rules follow a 3-tier format and are similar to the ASTM emergency standard ES 38-94. Presently, the rule change affects only soil cleanup criteria. Legislative authority for the rule change was passed by the South Dakota 1994 legislative session (HB 1085).

Adoption of risk based standards in South Dakota has raised many questions concerning the basic numerical justification for the standards and sociological concerns including property values, groundwater aesthetics, and future changes in property use. The rules are expected to be in effect by November, 1995.

Equus Beds Groundwater Recharge Demonstration Project, South Central Kansas

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Burns and McDonnell Engineering Company

Blain, G. T.
City of Wichita, Kansas

ABSTRACT

The Equus Beds Groundwater Recharge Demonstration Project is a small-scale $3.4 million trial project implemented to test the feasibility of a full-scale $106 million recharge project in the Equus Beds Aquifer. The project includes capture of bank-storage groundwater by induced infiltration during "above-baseflow" conditions and storage of water by direct injection and infiltration basins. Water will be captured using wells adjacent to the Little Arkansas River. Surface water diversion and recharge will also be evaluated. Presently pumpage exceeds the aquifer's natural recharge. With overdevelopment, changed groundwater gradients resulted in the aquifer being threatened by natural saltwater from the Arkansas River and oil field brine. The demonstration project includes several phases of investigation, construction of testing facilities, and pilot operation to determine the feasibility of the concept, develop design and operation criteria for the large-scale project, and obtain State approval. Work will continue through 1999.

Bioavailability

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ABSTRACT

Bioavailability is a measure of the extent to which organic compounds, particularly contaminants, in soil and groundwater are available for microbial uptake and mineralization. Because biodegradation of contaminants must take place in the aqueous phase (either the bulk water phase or the pore water phase of the soil vadose zone), contaminant partitioning is of primary importance in determining bioavailability. The sorptive properties of the contaminant to the soil, contaminant volatility and solubility influence bioavailability, and subsequently biodegradation rates. In saturated soil systems, adsorption/desorption is the most important factor in determining if the presence of a bulk soil phase retards biodegradation rates. In the unsaturated soils studied here, the effects of soil moisture content on biodegradation were also determined. Vadose zone soils contaminated with BTEX compounds from a pipeline leak site in Montana were modeled using a non-dimensional bioavailability factor, which expressed experimentally as a ratio of biodegradation rates in soils versus liquid culture, or mathematically as the ratio of the kinetics of sorptive reactions versus biodegradation reactions in a soil. Results validate the model for the bioavailability factor, and show that this factor increases with increasing soil moisture in unsaturated soils. The bioavailability model can thus be extended to unsaturated soils.

Fractured Aquifer Groundwater Flow Simulation

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ABSTRACT

Groundwater numerical modeling was conducted at a groundwater remediation site in south-central Kansas. The purpose of the groundwater modeling effort was to simulate groundwater flow in a fractured limestone aquifer with inherent recharge/discharge characteristics and to determine the feasibility of using an interceptor trench to create a hydraulic containment barrier at the site. A U.S. Geological Survey three-dimension finite difference ground water flow model (MODFLOW) was used to conduct the groundwater flow simulations. The "telescope technique" was used to minimize the local subdomain groundwater flow boundary affects after the interceptor trench was in operation. The model was calibrated manually for the purpose of incorporating site specific geological information over the regional domain and local subdomain. A very fine grid was used for the local subdomain in the vicinity of the containment barrier to characterize fracture flow and to simulate different trench design scenarios. Irregular boundary shape and complex boundary conditions including a constant flux boundary were considered in the modeling process. An optimized pumping rate was selected through simulations and the capture zone was estimated based on the flow modeling results. In addition, by performing groundwater modeling in this complex hydrogeologic environment, the major fracture orientations and the interaction of the aquifer and a nearby creek were estimated in the modeling process.

Determination of Site-Specific Soil and Groundwater Cleanup Levels Using a Health-based Risk Assessment Approach

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ABSTRACT

The presence of unacceptable concentrations of contaminants in underlying ground water and soil is common to an increasing number of heavily industrialized sites worldwide. As a result, contamination evaluations and mitigation measures are necessary for many industrial sites. Health-based risk assessments are often employed to establish soil and groundwater cleanup levels. The U.S. EPA's Preliminary Remediation Goals (PRG) developed using a health-based risk assessment approach serve as a very general guidance, but do not consider certain site specific factors including site-specific hydrogeologic conditions, exposure pathways and potential receptors. Site-specific risk and exposure assessment is often necessary to determine reasonable, prudent and cost-effective cleanup levels.

Presented herein is an example of the application of a site-specific health-risk and exposure assessment conducted for an RCRA closure site in southern California using the American Petroleum Institute's Decision Support System (API DSS) software. This presentation illustrates how a site-specific health-based risk assessment was performed using the API DSS model. This presentation also shows how the site-specific conceptual model was developed, and discusses identification of likely contaminant source area, determination of exposure pathways and selection of potential receptors. This presentation also illustrates a conservative risk/assessment modeling procedure using model sensitivity analysis.

Experimental Study on the Reduction of Saturated Hydraulic Conductivity Caused by Enhanced Biomass Growth

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ABSTRACT

The effect of bacteria growth on soil hydraulic properties is of great importance to groundwater recharge, water treatment or disposal processes, enhanced oil recovery schemes, and in situ bioremediation of organic contaminants. The research on it has been drawing increasing attention from scientists of various disciplines. In this research, soil column experiments were carried out to study the reduction of saturated hydraulic conductivity by enhanced biomass growth. Mineral salts medium and glucose solution of various concentrations were employed to enhance the growth of indigenous bacteria in soil. The soil used in the experiments was a mixture of fine sand with soil from the dumping site of a refinery plant. Rapid reduction occurred about 3 days after the application of the glucose solution, and the hydraulic conductivity of the soil column stabilized at about 10 days after the application of the solution. About 2 orders of reduction in hydraulic conductivity was observed.

Poster Abstracts

(Abstracts arranged in alphabetical order according to the name of the first author.)

Laboratory Evaluation of Microbial Transformations of Coal Tar Constituents in Three Low Redox Aquifers

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Department of Zoology and Physiology
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An estimated 1.5 million gallons of coal tar is distributed throughout the three aquifers that comprise the largely anoxic groundwater system beneath North America's largest former manufactured gas plant (MGP). Technological limitations to source removal at this site necessitate consideration of intrinsic bioremediation as part of the aquifer restoration strategy. The objective of this study is to evaluate the role of low redox microbial processes in the natural attenuation of MGP wastes. A three-phase anaerobic microcosm study was performed under sulfidogenic and methanogenic conditions. Naphthalene degradation was observed under both sulfate-reducing and methanogenic conditions. To our knowledge, this is the first laboratory evidence of naphthalene biotransformation during sulfate reduction. Toluene transformation with sulfate was rapid (<5 days), while benzene required longer periods of exposure (>120 days). Confirmation studies using radiolabeled substrates is currently underway.

Controls on the Distribution of Copper in Surface Waters Associated with the Ferris-Haggarty Mine, Carbon County, Wyoming

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Drainage from the Ferris-Haggarty mine in southern Wyoming has contaminated Haggarty Creek with up to 770 ppb dissolved Cu at the initial point of drainage to 20 ppb dissolved Cu about three miles downstream. The pH of the creek is slightly basic (7.0 - 8.0) and contains no significant contaminants other than copper. However, these copper concentrations exceed the toxicity levels for many organisms, and have destroyed a viable trout stream. The distribution of dissolved copper at the mine is controlled primarily by the solubility of an amorphous copper silicate which has precipitated in settling ponds located between the mine portal and Haggarty Creek. In Haggarty Creek, dilution significantly reduces copper concentrations. However, these concentrations may also be influenced by solid phases found in the stream sediments. A low dissolved organic carbon concentration (.8 ppm) in Haggarty Creek suggests that complexation to organics does not significantly affect dissolved copper levels.

Possible Sorption Specificity of Organo-clays

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Clays that are found naturally in the environment contain inorganic cations, e.g. Na^{+} and Ca^{++}. These ions cause the surface and interlayer spaces of the clays to be hydrophilic due to the cations being strongly hydrated. Smectites, such as montomorillonite, tend to have very high cation exchange capacities (CEC) compared to other clays such as kaolinite. The large CEC of smectites arises from vacancies created by substitution of A13+ for Si4+ and Mg2+ and Fe2+ for Al3+ in the clay lattice. The hydrophilic nature of the clays strongly affects their ability to sorb neutral organic materials. The hydrophilicity of natural clays can be modified and controlled by exchanging cationic surfactants for inorganic cations.

Exchange of the surfactants of the form [(CH 3) 3 NR]+ or [(CH 3) 2 NRR']+ with inorganic cations, where R is an alkyl hydrocarbon of 12 carbons or more, creates a hydrophobic clay. The surfactants are thought to form an organic phase which acts as a partition medium for extraction of neutral organic compounds. This modification causes the clays to sorb significantly larger amounts of hydrophobic organic compounds than clays without the modifier. We are interested in the possibility of making the organo-clays selective to certain groups of molecules (i.e. chlorinated ethylenes). We will be presenting data that will show whether or not a surfactant that contains a chloride group is a better sorbent for chlorinated ethylenes than the same surfactant without the chloride group.

Assessment of Groundwater Sensitivity and Vulnerability
Goshen County, Wyoming

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Geographic Information System'
Wyoming Water Resources Center
University of Wyoming

A modified form of the DRASTIC method was used to assess aquifer sensitivity and groundwater vulnerability in Goshen County, Wyoming. Appropriate hydrogeologic data were identified, obtained and entered into Geographic Information System (GIS) format at a 1:100,000 scale. Data were obtained for bedrock geology, surficial geology, digital elevation contours, and well records. From this basic data, selected parameter maps were generated including depth to water, net recharge, hydrogeologic units, soil units, slope of land surface and saturated hydraulic conductivity.

Mathematical functions were developed to calculate an aquifer sensitivity rating for quantitative hydrogeologic parameters (depth to water, hydraulic conductivity, etc.). Calculation of the sensitivity ratings was performed with a GIS operating on a raster-based file. For descriptive hydrogeologic data (geology, soils, etc.), sensitivity ratings were assigned based on the inherent capacity to transport or attenuate contaminants. A final ground-water sensitivity map was generated by combining/overlaying the rated parameter maps. A groundwater vulnerability map was then generated by overlaying a land use map on the sensitivity map.

Goshen County represents a pilot effort to develop a methodology to be used to assess aquifer sensitivity and vulnerability in each county in Wyoming. A set of sensitivity/vulnerability maps will be generated at a 1:100,000 scale. These maps will enable state and local planners to identify areas where the potential for groundwater contamination may be a concern. These areas can then be targeted for increased management.

Adsorption of Oxalate on g-aluminum Oxide

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The adsorption of oxalate ions on aluminum oxide is an important step in the ligand catalyzed dissolution of aluminum oxide. The adsorption of oxalate ions is monitored by attenuated total reflectance FTIR, using a flow cell designed for this purpose. This experimental approach allows for convenient control of oxalate concentrations. This approach may also allow one to study desorption phenomenon. From the data obtained from these experiments, adsorption isotherms can be obtained.

Chemical and Biological Transformations of Quadricyclane and Tricyclo[2.21.$0^{2,6}$]heptan-3-ol

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Quadricyclane (tetracyclo[3.2.$0^{2,7}$.$0^{4,6}$]heptane), a strained saturated hydrocarbon, is a potential environmental contaminant through its uses as a jet fuel additive, a solar energy conversion and storage medium, and in optical memory storage. Quadricyclane is stable in sterile deionized water, but rapidly transformed to tricyclo[2.2.1.$0^{2,6}$]heptan-3-ol and bicyclo[2.2.1]hepta-5-en-2-ol in both aqueous media and in soil. The rates of these strictly abiotic reactions are enhanced with increasing ionic strength. The tricyclo-alcohol is the most abundant transformation product and is persistent in the absence of soil microorganisms; it is eventually biotransformed into a methyl-cyclohexadineone derivative. The bicyclo-alcohol appears to be both chemically and biologically stable over a period of several months. Preliminary toxicity studies in our laboratory suggest that quadricyclane and its transformed products are inhibitory to bacterial cell growth. They are toxic to pure cultures of Pseudomonas with LC_{50} <1 mM.

Chromatographic Detection of Organic Compounds Using Surface Enhanced Raman Spectroscopy

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A new detector has been developed that couples SERS technology with the separation advantage provided by gas chromatography. This is a method of using SERS as a viable analytical technique for rapid quantitative and qualitative analysis of dilute aromatic mixtures. Results include evaluating SERS spectra for BTEX as a function of retention time along with isotherms for detection limits. Further research involves developing a universal SERS-based chromatographic detector for use in LC, CE, and SFC. Discussions will include technique sensitivity and several applications that demonstrate the potential of these techniques.

Geochemical Modeling for Assessing Aqueous Selenium Speciation

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Selenium (Se) speciation is important for understanding the fate and mobility of Se in surface and groundwaters and soil solutions. Aqueous mine soil solutions were assessed using two geochemical computer models (MINTEQA2 and GEOCHEM). The results of the models indicated Se species and complexes were not calculated in the same way by the two models. This was attributed to the inclusion of dissolved fulvic acid by GEOCHEM, whereas, MINTEQA2 considered only the inorganic species. In addition to SeO_3^{-2} (selenite) and SeO_4^{-2} (selenate), other solution species including $HSeO_3^{-1}$ (biselenite) and $HSeO_4^{-1}$ (biselenate) were also predicted by the models. Nonionic complex species were also determined by the models, which included: $H3SeO_3^0$, $CaSeO_3^0$, $MgSeO_3^0$, $CaSeO_4^0$, $MgSeO_4^0$, $MnSeO_4^0$, $ZnSeO_4^0$. The speciation analysis indicated the soils were undersaturated with respect to the Se solid phases used in the models, which included $CaSeO_3.2H_2O$, $MgSeO_3.6H_2O$, $MnSeO_3.2H_2O$, $CuSeO_3.2H_2O$ and $CaSeO_4.2H_2O$.

Investigation of Microbial Communities Responsible for Degradation of Toluene in Exposed and Unexposed Soils

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ABSTRACT

Population dynamics are seldom incorporated into investigations of organic contaminant degradation. In this study, we will use a combination of microbiological methods to elucidate the portion of a bacterial community responsible for contaminant degradation, and determine how the population density changes with time. Soils with no previous toluene exposure versus soils treated with toluene will be compared. Biometer flask microcosms amended with ^{14}C-labeled toluene will be used to determine the proportion of microbial activity attributable to toluene degraders. A ^{14}C-most-probable-number (^{14}C-MPN) technique, in combination with acridine orange direct counts (AODC), will be used to enumerate cell numbers. Evaluation of these data will give insight to microbial population dynamics and relationships between cell numbers, activity and degradation rates. Bioremediation modelers may use this information to develop more accurate and effective models for restoration of remediation sites.

"Fingerprinting" of Petroleum Products Using GC/FID

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Petroleum products are routinely analyzed by gas chromatography using flame ionization detection (GC/FID). A technique has been developed to divide the chromatogram into distinct boiling point ranges based upon the boiling points of known, aliphatic hydrocarbons. Each boiling point range is considered as a percentage of the total petroleum hydrocarbons and graphed. Comparison of unknown petroleum contamination can be analyzed using this technique and identifications made as to type, and in some instances age, of the contaminating materials. Comparisons can also be made to known materials existing in tanks to determine if a release has occurred from the tank.

Distribution Coefficient (K_d) Values for the Partitioning of Cu Between Wyoming Soils and Pore Waters: Initial Results

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Predictive models for transport and retention of metal pollutants require a partition coefficient, K_D, to calculate the fraction of metals which adsorb to soil surfaces, and the fraction which remains dissolved in pore waters. K_d values are affected by the many chemical equilibrium reactions which operate in soil environments; therefore, they are conditional for a given soil-water environment. Previous studies suggest that the most critical variables to affect K_d values are the concentration of Fe/Mn oxides and organic matter in soils, and the pH and ligand concentration in pore waters.

We report initial results for our evaluation of K_d values for Cu in a suite of 9 Wyoming soils. The soils are Aridisols, Inceptisols, and Entisols, collected near Laramie, Wyoming, and are characterized by organic carbon concentrations of 0 - 5%, extractable Fe concentrations of 0.1 - 1%, and 0 - 40% clay content. K_d values vary by orders of magnitude depending upon soil type and solution pH.

Immobilization of Contaminants With In-Situ Calcite Precipitation

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Recent experimental studies suggest that complex anions may substitute into calcite structure during the growth. The objective of this study was to immobilize selenite (SeO_3^{2-}), selenate (SeO_4^{2-}), arsenite (AsO_2^-), and arsenate (AsO_4^{3-}), cadmium (Cd^{2+}), copper (Cu^{2+}), and lead (Pb^{2+}) with in-situ calcite precipitation. For this research a specially designed column of 60 cm in length with a diameter of 2.5 cm was used to study adsorption and incorporation of contaminants during the in-situ precipitation of calcite. This was achieved by bubbling CO_2 through a $CaCl_2$ and CaO system containing contaminants. Periodically a sample was taken from the column and analyzed for pH and concentration of contaminants. The precipitated calcite was filtered, and analyzed with the X-ray diffraction, and the Scanning Electron Microscope. The ability of in-situ precipitation of calcite to immobilize contaminants in aqueous solutions will be discussed.

Analysis of Concentration Fluctuation in Heterogeneous Aquifers

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For the management of groundwater contamination, it is necessary to predict the concentration distribution of the contaminated species in groundwater. Because of the heterogeneity of the formation, the mean concentration predicted by the convection-dispersion equation has a large uncertainty. The concentration variance is an important index to indicate the fluctuation behavior of concentration distribution. Based on a spectral perturbation approach, a conservation equation of the concentration variance was derived. In the equation, the concentration variance was described by convection and dispersion with a mean water velocity and macrodispersivity. There was a new production term in the equation. The production term was proportional to the squared mean concentration gradient with a proportional coefficient defined as productivity. The productivity depends upon the statistical properties of the soil and the local dispersivity. Sensitivity analysis was carried out to demonstrate the effects of variant parameters, such as the variance and the correlation length of log hydraulic conductivity, and the local dispersivity, on the concentration variance.