

Minnesota Ground Water Association

Volume 8, Number 4: December, 1989

Winter Meeting: Solute Transport in Fracture Networks

Mark your calendar now: MGWA, Macalester College, and the University of Minnesota have invited the Birdsall Lecturer, Leslie Smith, to lecture in the Twin Cities. He will speak at 7 pm, February 28th, in the Macalester chapel. A reception in the chapel lounge will follow. Macalester has plenty of parking and the chapel is easy to find (see map on next page, it is the hexagonal building south of Grand Avenue).

Leslie Smith, Department of Geological Sciences, University of British Columbia, is the 1990

Birdsall Distinguished Lecturer. Smith received his Ph.D. in geology from the University of British Columbia.

He has carried out research on stochastic simulation of fluid flow and mass transport in heterogeneous porous media, mass transport in fractured rock masses, and the role of groundwater in geodynamic processes. Smith is a recipient of the Meinzer Award of GSA, and the Macelwane Medal of the American Geophysical Union.

Dr. Smith's talk on solute transport in fracture networks is summarized as follows: "Numerous observational data indicate that solute transport can be strongly influenced by the geometric properties of a fracture network within a low-permeability rock mass.

What is less clear is how various mass-transfer processes, which act on a number of different scales, interact to determine transport patterns and solute concentrations, and how we can develop quantitative methods to describe solute transport in a fractured rock mass.

The objective of this lecture is to examine progress in dealing with this issue. Traditional approaches based on either deterministic concepts or an assumption of porous medium equivalency have not yielded substantial progress in our capabilities of quantifying solute transport in geologic media where fractures dominate the character of the flow system. Stochastic concepts appear central to future ad-

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President's Page

Team Work

Most people think of "teams" and "team work" as applied to sporting activities. Team work can also enhance professional and job-related activities. The "teams" may be within our own companies or organizations or may include a consultant, a client, and several contractors as well as many other combinations.

One reason to form a team is when a task requires more knowledge, skill, time, or experience than an individual has available to achieve a certain goal. Occasionally one person may have all of the attributes necessary to accomplish a certain task but efficiency and effectiveness may be lost.

The mutual dependance on the other team members is something that feels uncomfortable to many people. If one member of the team does not fulfill his or her obligations, the whole team may suffer. Good

communication among the team members is important; their mutual dependance should result in a better solution to the problem or task than that produced by an individual working independently.

Shared recognition implies shared accountability for all results of the team's activities. A team that is not accountable as a team will be just a group of independent operators without a unified mission.

Good communication will help to define the roles of each team member, schedules and procedures to be followed in accomplishing the objectives, and discussion of problems and solutions. Discussion, debate, and disagreement may occur during the course of problem solution. The team must examine points of discussion and seek to resolve disputes.

Successful team work is often enhanced by an effective team leader. The team leader must maintain the team's focus, set schedules, and supply necessary resources to the team. The leader reinforces cooperation and mini-

mizes internal competition or private agendas.

A good team leader shouldn't dominate but should share decision making through consensus building and recognition that some team member's skills may overshadow their own. The leader must listen and respect other's opinions.

- Bob Karls

Table of Contents

Winter Meeting	1
Minnesota Water 1990.....	4
New Members	5
Seneca WWTP/Nicols Fen. 6	
Dakota Water Quality Study 8	
New Officers.....	9
LCMR RFP	9
New Advertising Policy.....	9
Congressional Update.....	10
Project Management Workshop	12
1990 MGWA Directory.....	12

cepts appear central to future advances in this area."

Dr. Smith will also lecture at 2:30 pm at the University of Minnesota, in room 207C of Pillsbury Hall, on the topic of Ground Water and Tectonic Processes. The membership of MGWA is invited to attend.

The topic is summarized as follows: "Pore waters are an integral part of geodynamic processes that occur within the upper ten kilometers of the earth's crust. There are two basic reasons that this is the case: 1) fluid pressures influence the mechanical strength of rock and thus deformation processes, and 2) fluid flow is the key process for large scale redistribution of mass and heat within crustal rocks. The nature of the coupling of the hydrologic, thermal, and stress regimes will be examined, using as examples earthquake rupture and advective redistribution of thermal energy. Non-linearities and feedback loops play an important role in system behavior. The lecture will conclude with a discussion of gaps in our

knowledge base that limit the extent to which quantitative models can be applied to simulate fluid flow and mass and heat transfer on a geologic time scale.

Future of Hydrogeology

The 1989 Birdsall Distinguished Lecturer was Warren W. Wood. At the conclusion of his tour, which included 31 universities, he wrote a synopsis of his observations.

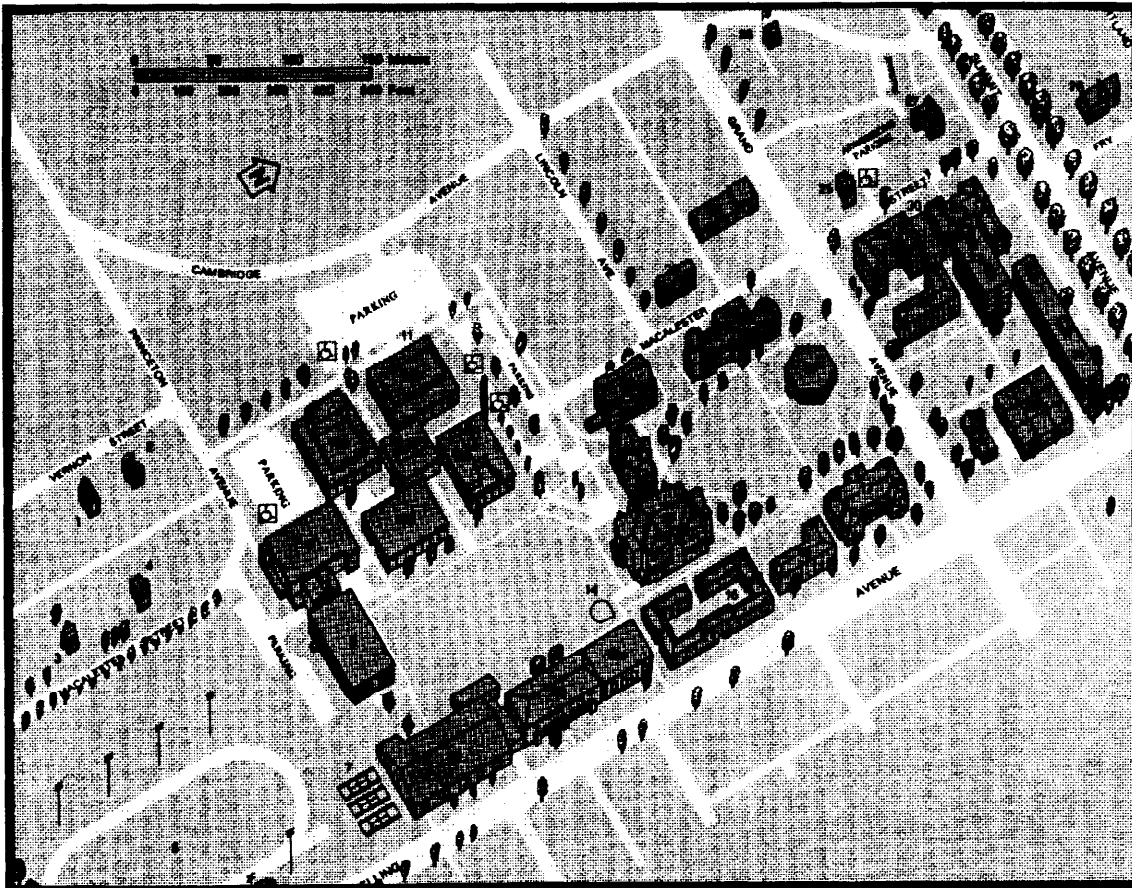
"Like my predecessors on this tour, I observed several trends that I think may be of interest:

- The most obvious is the small number of PhD candidates. The job market is so good (\$30,000+ for individuals with an MS degree and no experience) that there is little short-term incentive to stay on for a PhD.
- I also notice the general lack of well-equipped research labs. Some were outstanding, a few were adequate, but most were much less than would be desired

in terms of equipment and space.

- With some exceptions, I saw little evidence that teaching laboratories were utilized in hydrogeology courses. I think this is unfortunate for two reasons: First, a physical demonstration frequently allows the student to relate abstract principles to physical processes; second, as soon as many of the students graduate and start to work they will be requesting a variety of lab tests of their clients without knowing the limitations of the tests they are requesting.
- There are few field courses that cover the fundamentals, such as aquifer tests, drilling methods, water-rock-, or gas-sampling techniques, piezometer installation, surface and borehole geophysics, chain-of-custody, and field notebook procedures.
- PC's have nearly replaced the mainframe or minis as the computing tool of choice in many schools; only a few have the new

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sophisticated work stations.

- I was initially concerned that contaminant hydrology was driving the system with such intensity that we were producing nothing but "plume buster"; however, this does not seem to be the case. Although some departments seem to emphasize "Plume Busting", most researchers are working on fundamental hydrologic and geologic processes.

If this is where we are now, where does the future lie in terms of intellectual breakthroughs, and what is the stature of our profession and how will it change?

In the field of contaminant hydrogeology, I expect the greatest new contributions to be in gas and particulate (organic and inorganic) transport.

This will occur as we realize that we must deal quantitatively with all three phases, not just solutes. In a larger sense, it's my opinion that we will see new efforts applying the quantitative techniques that we have developed for contaminant hydrogeology to classic geologic problems, such as cementation, porosity development, geomorphology, fluids in metamorphism, structural and tectonic problems, ore deposition (both metallic and non-metallic), compacting basins, hydrology of diving plates and rift zones.

In other words, we will expand from our traditional view of water supply and protection (water resources) philosophy into a broader view of "fluids in subsurface geologic processes". It is also my opinion that this orientation will eventually enhance our prestige among other geoscientists, and, thus, find acceptance of a modified form of hydrogeology in a larger core of geoscience departments.

Presently, there are no hydrogeologists in the National Academy of Science. Paul Witherspoon is the only one that I am aware of in the National Academy of Engineering, and Paul was selected only this year and as a petroleum engineer. It appears that our scientific and engineering colleagues do not have a very high opinion of the work we do. Ap-

parently it is their perception that we are not working on or solving fundamental problems. If this is the case, then perhaps our broadening of interests into traditional geologic problems may gain us the recognition of our colleagues in other sciences.

Where will the hydrologists come from? My guess is that in the future there will be more from the field of engineering and fewer from the field of geology. I say this after just proposing that the next breakthroughs will be in geologic applications.

The reasoning is as follows: Enrollment in undergraduate geology is currently depressed due to the decline of the petroleum industry; thus, not only are there fewer students in geology programs that might study hydrogeology, but many deans are reluctant to replace existing faculty openings in geoscience departments, and certainly are not likely to open new positions for "high priced" hydrologists. In addition, many geology departments appear unwilling to modify the traditional mix of courses that have served them in the past.

Coupling this with the aggressive attitude of some engineering departments in expanding their role in ground water, their traditionally higher salaries to attract faculty, and the ultimate shift in contaminant hydrology toward remedial action, the result is that the students with an engineering background will predominate.

In summary, it appears that contaminant hydrogeology will continue to provide excellent employment opportunities with a larger share of professionals coming from engineering backgrounds than in the past. However, I think that the real challenge and many of the significant breakthroughs will come from the application of quantitative hydrology to traditional geologic problems."

Lecture summaries and Warren Wood's comments are reprinted from the September, 1989 issue of "The Hydrogeologist", the newsletter of the Hydrogeology Division of the Geological Society of America.

Delta wins PSMA Human Resources Award

Press Release from PSMA

The firm of Delta Environmental Consultants, Inc., of St. Paul, captured first place in the 1989 Annual Management Achievement Awards Program sponsored by the Professional Services Management Association (PSMA).

The firm's entry was in the category of "Human Resources" and consisted of successfully attracting job applicants and building employment through development and implementation of a recruiting advertising campaign. Qualified applicants increased 500-fold in just three months after the campaign began, and in less than a year, employment grew by 250 percent.

Delta's was one of 20 entries in five categories of PSMA's awards program. The firm's entry described how it was able to increase employment despite being, as a two-year-old firm, virtually unknown in the professional community.

"Growth for us was limited not by the ability to attract new business," said Polly Fabrizio, vice president of planning and development for Delta, "but by the number of applicants meeting our qualifications and availability for hire. Competition for qualified candidates, especially hydrogeologists and engineers, is keen. Our interview process is sound; our biggest selling points are culture, work environment, and the support and freedom to devote attention to clients' projects. The problem was attracting applicants in the first place."

Delta's solution was an advertising campaign using full-page, four-color ads in major technical publications. Delta's ads were designed to quickly capture readers' attention with dominant photographs and crisp, concise text. A long-term campaign included one to three insertions a month, with repeat coverage over time.

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The initial campaign featured three ads:

- **We hire those who aim higher** headlined a mountain climber.
- **Like to make waves? Welcome aboard!** featured white water rafting.
- **Reaching the top takes a lot of support** showed two climbers scaling a glacier.

"Qualified applicants increased from 10 a week to over 50 a week after just three months" Fabrizio said. "The number of employees grew from 120 in September 1988 to 300 in August 1989."

Delta, founded in 1987, provides consulting and project management services for environmental problems. In addition to its Minnesota headquarters, Delta has offices in Florida, Colorado, Arizona, California, North Carolina, New Jersey and Texas.

Software Library

The Minnesota Ground Water Association has acquired a set of educational water-resources software programs. These learning tools are to be made available to members on a loan basis at no cost.

The software requires an IBM-compatible PC and a color monitor with an IBM Color Graphics Adapter (CGA), the EGA and VGA monitors won't work.

The four programs cover the following topics:

- Surface Water
- Ground Water,
- Hydrologic Cycle, and
- Moisture in the Atmosphere

Each topic has color graphics, scientific terms, and definitions designed for students high-school level and above. Arrangements to borrow these programs can be made by contacting Lee Trotta at (612) 229-2623 for details.

If you have any software of a similar nature which you could donate to MGWA for this purpose, please give Lee a call at the above number.

Minnesota Water 1990

The Water Resources Research Center at the University of Minnesota has announced the dates and location for the second biannual conference on Minnesota's water resources. *Minnesota Water, 1990* will take place April 9 and 10, 1990 and will be held at the St. Paul Radisson Hotel in downtown St. Paul. The two-day meeting will be cosponsored by the WRRC, the Water Resources Committee of the Minnesota Environmental Quality Board (on behalf of the state water agencies), the U.S. Geological Survey (Minnesota District), and the Freshwater Foundation.

Co-chairs of the committee are Patrick Brezonik, director of the WRRC, and John Wells, coordinator of the EQB's Water Resources Committee. A conference planning committee has been formed consisting of 12 representatives from the sponsoring organizations, state water agencies, and University of Minnesota Water Centers.

Conference format will include a plenary session Monday morning (theme: Minnesota's water resource challenges and opportunities for the 1990's); concurrent

technical sessions both afternoons; a poster session Tuesday morning featuring results of current research on water issues and problems in Minnesota; and computer workshops on Tuesday morning.

Half-day oral sessions are being organized on the following topics:

- Agricultural management practices to minimize surface water and ground water contamination.
- Atmospheric contamination of Minnesota lakes and wetlands/aquatic weed issues.
- Drinking water supply and treatment issues.
- Lake Superior research symposium.
- Local water planning and the state water plan.
- Recent developments in spatial analysis of water resources.
- Social and economic issues and Minnesota's water resources.
- Surface and ground water monitoring in Minnesota.

Poster papers will not be limited to the topics listed above. Poster papers on the full range of water issues of concern in Minnesota are solicited. Please send a title, author and 75-100 word abstract of your poster paper to the WRRC by January 25, 1990.

Phillips - AWG Distinguished Lectures

Phillips Petroleum Company has awarded \$9000 over three years to the Association for Women Geoscientists Foundation to support travel expenses for the AWG Speaker's Bureau. Institutions and associations are invited to apply for travel grants for speakers. AWG's Speaker's Bureau provides a listing of nearly 100 nationally-recognized women geoscientists across the country with a wide range of topics.

Awards are available to institutions/organizations to cover up to \$300 for travel for a speaker listed with AWG's Speaker's Bureau.

Awards will be made only to non-profit, non-governmental institutions or organizations. In the first year of the program, travel for only one talk per institution/organization will be funded. Each speaker will be funded only once per year.

Current listings of speakers and other information about AWG's Speaker's Bureau can be obtained from:

Speaker's Bureau
Association for Women Geoscientists
Resource Center for Associations
10200 West 44th Ave. #304
Wheat Ridge, CO 80033-2840.

New Members

Bill Bangsund, Barr Engineering Company
Mike Bares, Minnesota Pollution Control Agency
Dr. Erv Berglund, DNR Minerals, St. Paul
Jane C. Boerboom, STS Consultants, Ltd.
Terry L. Bovee, LeSueur Co.
Roger Carpenter, Leggette Brashears & Graham
Paula Connell, Braun Environmental Laboratories
Diane Desotelle, Leggette Brashears & Graham
Kathleen Dittman, Foth & Van Dyke
John Forrest, Dakota County Planning
Elizabeth Gawrys, Minnesota Pollution Control Agency
Andrew Graham, Nova Environmental Services
Jeffery Alan Groen, Limnological Research Center, University of Minnesota
Clay Gustafson, Washington County Public Health Department
Amy K. Hadriaris, Minnesota Pollution Control Agency
Mark Hagley, Barr Engineering Company
Jane Harper, Washington County Public Health Department
Dr. Keith Harris, Minnesota Geological Survey, University of Minnesota
Brain T. Hayden, RREM, Inc.
Loren M. Hubert, STS Consulting, Ltd.
Philip Jaguki, Malcom Pirnie, Inc.
Bruce Johnson, Twin City Testing, St. Paul
Helmer O. Johnson
Terry Kaiser, Barr Engineering Company
Ellen Kirschner, University of Minnesota
Larry Kramka, DNR - Division of Waters, St. Paul
Leonard Kremer, Barr Engineering, Company
Matt Landon, University of Minnesota
Inez Lang, Land O'Lakes
Bob Leibfried, DNR - Division of Waters, Grand Rapids
Brian K. LeMon

Jeff Luehrs, Dakota County Public Health
Richard Manser, Geraghty and Miller, Inc.
Barbara J. McAvoy
Bryan McGinnis, Rice Creek Advisory Committee
Elizabeth M. Metzen, Barr Engineering Co.
Cathy O'Dell, Geraghty and Miller, Inc.
Reuben M. Olson
Camilia Pederson, GME Consultants
Melisa Pollak, Minnesota Pollution Control Agency
Bernd W. Rehm, RMT, Inc.
Paul Robinson, The Valspar Corp.
Bruce Sampson, Sampson Well Co., Forest Lake
Kiff J. Samuelson, RREM, Inc., Duluth
Rexford Singer, University of Minnesota
Mel Sinn, Board of Water and Soil Resources
Eric A. Smith, RREM, Inc., Duluth
Rennie Smith, Twin City Testing Corporation
Betty J. Socha, Foth & Van Dyke
Jeff Solheim, Terracon Consultants
Douglas A. Spaulding
Bill Stewart, The Valspar Corp.
Susan Thornton, Legislative Commission on Minnesota Resources
David Trumm
Scott J. Veitenheimer, RREM, Inc., Fergus Falls
Efie Wahlstrom, GME Consultants
James F. Walsch, Minnesota Department of Health
David Watterson, Bruce Liesch and Associates
Ron Weaver, Braun Environmental Laboratories
Earl Windahl, Braun Environmental Laboratories
Berhane Worku, Dakota County Public Health

Changes

Very few of you reported changes directly to us. If we got it wrong, it's because we had to use the grapevine! If you change jobs or move, call the editor in self defense!

Gretchen Sabel has joined the State Planning Agency to work on radwaste disposal siting.

Eric Mohring has switched to the Board of Water and Soil Resources.

Tom Gullett, **Laurel Reeves**, and **Jan Falteisek** have joined the Ground Water Unit in the DNR Division of Waters. Laurel and Tom will be working on the statewide observation well network, Jan will be coordinating a ground water contamination sensitivity project.

The **Tanks and Spills and Hazardous Waste Sections**, Hazardous Waste Division, Minnesota Pollution Control Agency have moved to Energy Park. Mail should still be sent to 520 Lafayette Road, but it will be hard to reach these staff because phone numbers have changed (so what's new about that?).

Dr. Keth Harris joined the Minnesota Geological Survey in September and will be in charge of the ground-water atlases.

Dave Armstrong is now with the U. S. Geological Survey in the ground-water section.

Dr. Jim Almendinger left the USGS (at least temporarily) to do post-doctorate work at Lund University in Sweden.

AGWT Awards Scholarships

Three ground water resource students have been awarded AMTROL/American Ground Water Trust (AGWT) Scholarships for this academic year. Each received \$2000 from an AGWT program supported by AMTROL, Inc. Undergraduates are invited to apply for scholarship support from the Trust by contacting AGWT, 6375 Riverside Drive. Dublin, OH 43017.

Innovative Approach to Fen Protection - Irrigate!

By Jeanette Leete and Tom Gullett, DNR-Waters

An interagency team of DNR-Waters and Minnesota Pollution Control Agency (PCA) staff is working together with the Metropolitan Waste Control Commission (MWCC) to prevent damage to a rare Minnesota habitat: the Nicols Meadow calcareous fen. The Seneca Wastewater Treatment Plant expansion and upgrade poses a potential threat to the nearby fen (see Site Map) if the flow of ground water to the fen is disrupted. Flow disruption is likely because construction plans include excavation and dewatering of a large area to facilitate construction of the expansion.

Calcareous fens are rare peatlands. Nicols Meadow fen is an example of the Minnesota River Valley fen type; only 4 areas of this type of wetland complex have survived. The three other fens in the river valley are Black Dog Fen, Savage

Fen and Fort Snelling Fen. They occur at the base of north-facing bluffs where a constant flow of cold, calcium-rich ground water makes its way toward the surface. Calcareous fens once stretched for miles along the Minnesota River valley until human activities such as road construction, ditching, and fire prevention caused widespread degradation.

Calcareous fens have been designated as Outstanding Resource Value Waters by the PCA. This classification means that state government must use all practical means and measures to preserve them.

The ground water regime which supports the remaining calcareous fens has been stable for several thousand years, relict plant species of early post-glacial climatic periods have survived in them. Other plant species cannot invade an undisturbed fen because they cannot tolerate the unfriendly conditions: cool temperatures and constantly wet oxygen-poor peat soil.

Nicols Meadow fen has rare plant populations of state-wide sig-

nificance; sterile sedge (*Carex sterilis*), valerian (*Valeriana edulis*), and three kinds of lady slippers grow there. These plants are protected under Minnesota's Endangered Species Act.

The treatment plant upgrade and expansion is also environmentally significant. The plant is being changed so that the discharged treated water will meet the standards of the Federal Clean Water Act.

Site preparation for the planned construction was started in late winter 1988. When impacts of the dewatering near the fen were recognized, the DNR Waters staff directed the installation, at MWCC expense, of two sets of water level observation wells. Each set has one shallow well and one deep well. Nested wells can reveal the vertical direction of ground water movement.

Water level measurements in these wells were first taken in early June, 1989. Initial ground water conditions were typical of a fen: ground water was moving upward (discharging or upwelling conditions). This was observed by comparing the water levels in the nested pairs of wells. If the water level in a deep well is higher than in a shallow well at the same site, water is moving upward.

As pumping at the Seneca site continued and pumping volumes were increased, the observation wells near the fen revealed a transition to recharging or downward movement of ground water (see Figure 2). Kennealy Creek, a trout stream between the fen and the Seneca site, was also apparently affected by dewatering. Compared to Harnack Creek, which is fed by a spring less than one-half mile to the west, flow in Kennealy creek decreased more rapidly during the early summer and ceased flowing altogether in late July.

Water levels in another fen in the Minnesota River Valley, Savage Fen, were monitored in order to have a comparison to a fen which was not affected by ground water withdrawals. In addition, peat water level monitoring wells were installed in the interior of Nicols fen. This comparison led to the conclusion that water levels in the fen

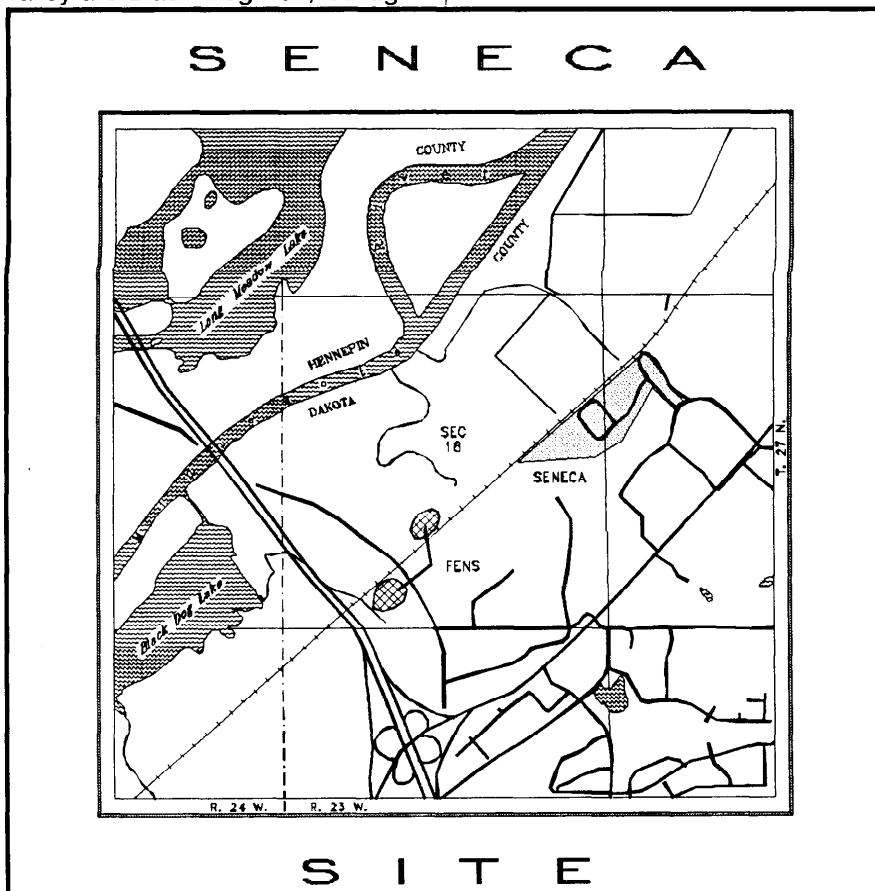
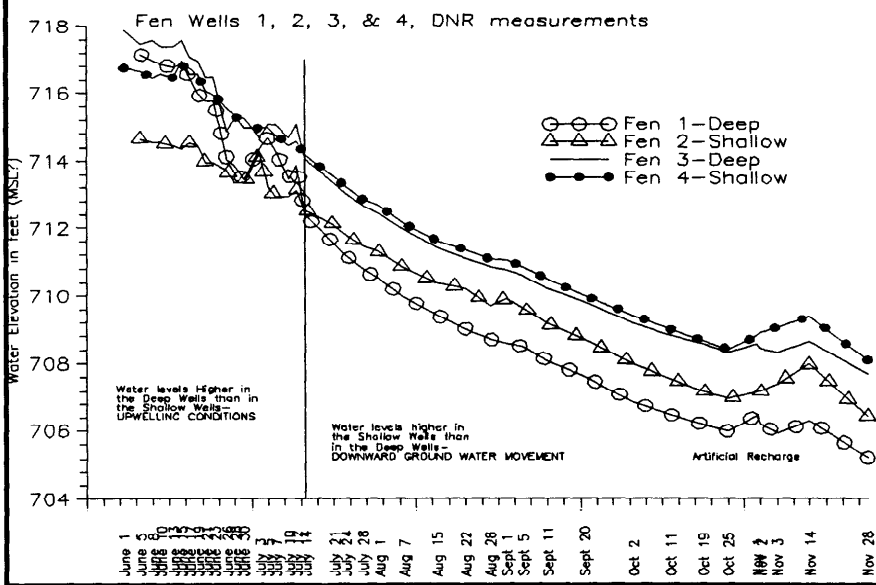


Figure 2: Response of Nested Wells to Dewatering and Irrigation.



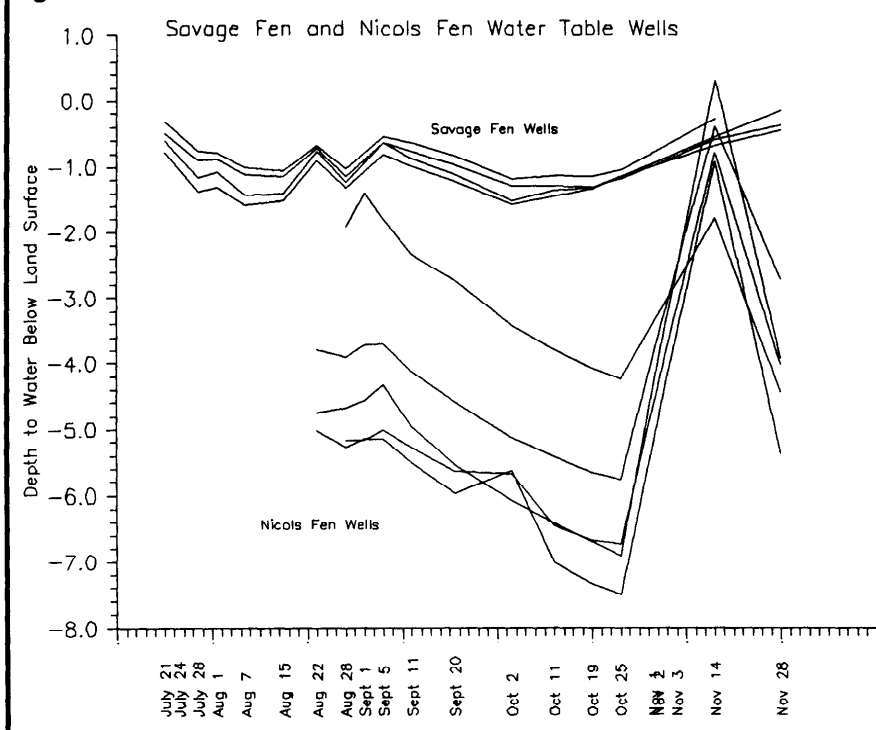
at the end of the 1989 growing season were at least 4 feet lower than the DNR's estimate of seasonal norms.

Given the low water conditions, the roots of the fen plants were in an unsaturated soil zone and would be exposed to winter temperatures and humidities without the protection of water. If sufficient moisture was not available prior to winter freeze-up, the roots might "freeze dry". This situation was deemed to be a serious threat to the native fen

species. In addition, the landowner and adjacent property owners had expressed concern that fire danger might be heightened and that ground subsidence in the fen might result from long-term dewatering.

DNR, PCA, and MWCC staff agreed that a temporary watering program should be carried out to irrigate the surface of the fen with ground water (pumped out of the ground at the construction site). The goal was to saturate the peat before frost. To avoid compaction

Figure 3: Water Table Wells in Peat.



and other physical damage to the fen, the irrigation guns were to be placed along the railroad right-of-way.

In less than two weeks from conception to first application of water:

- PCA staff effected a change in the dewatering project's National Pollutant Discharge Elimination System permit to allow water to be sprayed on the fen,
- MWCC staff negotiated an access agreement with the Chicago and Northwestern Railroad and obtained and installed the irrigation equipment,
- and DNR staff helped design the irrigation system, obtained the permission of the concerned landowner, Joseph Kennealy, assisted with fine-tuning of the spray pattern, and began to monitor the response to irrigation in the wells (see Figure 3).

Water was first sprayed on the fen on October 30. Water levels in the peat recovered rapidly and similar increases in water levels were seen in the nested wells. On November 14th irrigation had to be discontinued because of deteriorating weather conditions. Temperatures were predicted to be near or below freezing and the system could not be allowed to freeze with water in it.

After irrigation was stopped, water levels in all the wells declined (see Figure 2). DNR staff believe that the peat was at or near field capacity when it froze and that the goal of the irrigation project was accomplished.

Construction dewatering will continue into 1992, and some dewatering will also be required during the operation of the new plant. MWCC's consultant, HDR Engineering, is in the process of evaluating long-term mitigative measures to protect the fen. HDR's initial proposal includes a recommendation to recharge the ground water between the fen and the dewatering site with reinjection wells. The goal will be to allow ground water conditions under the fen to return to normal by the start of the 1990 growing season.

Graphics by Jerry Johnson and Jay Frischman

Water Quality Study Started in Dakota County

By Lee C. Trotta, U.S. Geological Survey, St. Paul, Minnesota

Dakota County has been the target of a lot of scientific reconnaissance work the past couple months. The U.S. Geological Survey, in cooperation with the Minnesota Department of Natural Resources, the Dakota County Soil and Water Conservation District, and the Minnesota Pollution Control Agency, began a project in November to study the effects of selected basin characteristics and depth to water table on the County's water quality.

Greg Mitton is in charge of describing the surface- and ground-water quality in the Vermillion River watershed, as related to these characteristics. Lee Trotta is in charge of constructing and comparing a computer-generated and a field-verified version of a depth-to-water map covering the entire county.

Water quality in the Vermillion River watershed will be described from water samples collected at from wells and streams. Having some of the wells located at the streamflow sites will allow the collection of samples that will represent a composite of ground-water discharge from the watershed. Water samples will be analyzed for ammonia, nitrate, phosphorus, and dissolved organic carbon. Samples from several sites also will be analyzed for selected "EPA Priority Pollutants". Immunoassay methods will be used to screen for the presence of triazine herbicide. In addition, the surface-water samples will be analyzed for suspended-sediment concentration, and suspended organic carbon. The results from these and other historical samples will be related to measurements of streamflow, temperature, urbanization, drift-thickness, depth-to-water, and other characteristics.

A depth-to-water map depicts the distance between the land sur-

face and the water table in the subsurface. A computer-generated depth-to-water map is produced using data from an existing digital data base. The existing data in this study is in a summary data base with well-location accuracy to the 40-acre parcel and a format compatible to the available geographic information system. The mapping of water-table conditions utilizes reported water levels from wells tapping Quaternary deposits. These wells in combination with available digitized coverages of soils and hydrography suffice for input to the computer-generated version. The study will review the permeability attributes of the soils coverage to indicate the occurrence of confining layers near the water table and will program appropriate adjustments to the depth-to-water isopachs.

Fieldwork done through Christmas has included measurement of water levels in 24 existing wells all across the county. One possible application of a depth-to-water map is to help indicate ground-water susceptibility to surface contamination. The feasibility of applying techniques developed in this pilot study to other counties will be evaluated by the Minnesota Pollution Control Agency and the Metropolitan Council.

Monitoring Wells

Call

Thein Well

1 - 800 - 992 - 8832

MPLS (612) - 464 - 1177

AWWA Scholarship

A St. Cloud State University (SCSU) earth science major has been awarded a scholarship from the North Central Division of the American Water Works Association. She is the first SCSU student to win the prestigious award.

Denise Victory of St. Cloud was one of four recipients of the award, which is based on career goals and progress in the earth sciences program. Victory will study hydrogeology in graduate school.

"St. Cloud State is different from most earth science programs," Victory said. "Because in most programs there are few women. However, our program is about 50 percent women."

- SCSU Alumni Newsletter, December, 1989.

Minnesotan is Master Well Contractor

MGWA congratulates Roger Renner of E.H. Renner & Sons, Inc., Elk River, who has successfully completed the Master Well Contractor Examination of the National Water Well Associations (NWWA) Contractor Certification Program and is entitled to use "MWC" after his name.

Renner is one of only a handful of contractors in this NWWA program who is qualified to take this special exam because of the prerequisites that candidates must have a minimum of five years active experience in the water well industry and must be currently Certified in all existing certification categories for water well drillers and pump installers.

The Certification program established standards of technical competency within the water well drilling and pump installing professions and tells the public that those who have qualified in the program have voluntarily met these standards. The Master Water Well Contractor has proven his knowledge in all aspects of the water well industry.

Legislative Commission on Minnesota Resources (LCMR)

Request for Proposals Offer of detailed RFP and Instructions

The LCMR will be accepting proposals for funding from three areas:

Minnesota Future Resources Fund (MS 116P.13) -- estimated amount available \$18 million.

- For new innovative or accelerative projects in the areas of: recreation, water, education, agriculture forestry, fisheries, wildlife, land, minerals, air, and waste.

Minnesota Environment and Natural Resources Trust Fund (MS 116P.08) -- estimated amount available \$5 million.

- For education, research, collection and analysis of information projects with long-term effects that employ an interdisciplinary approach to promote wise stewardship and enhancement of our state's environment and natural resources.

Oil Overcharge Money (MS 4.071) -- estimated amount available \$2 million.

- For projects resulting in decreased dependence on fossil fuels and for technology transfer with the same purpose.

To receive a copy of the detailed request for proposals contact:

John R. Velin, Director
Legislative Commission on Minnesota Resources
Room 65, State Office Building
100 Constitution Ave.
St. Paul, Minnesota 55155

Applications must be received at the above address by 4:30 pm, February 16, 1990

The LCMR will review and evaluate proposals during June and July of 1990 and submit its funding recommendations to the Legislature in August of 1990 for funding of projects during the 1992-93 biennium.

Eligibility: This application process is open to all.

New Officers Elected

Congratulations to our new officers. **Dr. Gordon Hess**, ERM North Central, was elected to serve a term as President Elect while **Bob Karls** is President. Gordie will be President in 1991.

Bob Beltrame, Donohue & Associates, was chosen to be our Secretary and Membership Coordinator.

Don Jakes serves one more year as Treasurer, and **Lee Trotta** continues as Newsletter Editor, but will cheerfully step aside if a volunteer can be found to assume his duties.

The revised Bylaws were approved as published in the October newsletter.

Response to our last balloting was less than overwhelming. The ballot was included as part of the newsletter to save about \$200 in postage and printing. We assume most of you were extremely interested in the outcome of the election, but you just couldn't bear to cut up the newsletter. The officers are open to any suggestions to improve 'voter turnout'. Any ideas for next time?

December, 1989

AGU assists students

Fred Spilhaus, Executive Director of American Geophysical Union, 2000 Florida Ave., N.W., Washington D.C., announced that the following scholarships and student travel grants are available.

The American Geophysical Union provides scholarship assistance: 1) For minority students in earth space and marine sciences through the American Geological Institute's Minority Participation program; 2) the Jane-Bacon-Berkey Scholarship for a woman in atmospheric sciences.

AGU also provides travel grants for student members who are presenting a paper at a spring or fall AGU meeting and step grants for foreign graduate students studying in the United States.

Newsletter Advertising Policy

Advertising space is available in this newsletter to businesses and organizations. Display ads (4 issues = 1 year) are charged by fractional page:

Size	inches	Annual Rate
business card	3.5x2.4	\$50
quarter page	3.5x5	\$90
half page	7x5	\$170
full page	7x10	\$320

Copy should be camera-ready.

The Editor has final determination on the acceptance of materials submitted. There are no commissions on ads. Advertising copy must be received by the publication deadlines: February 15, May 15, August 15, or November 15. The ad should be accompanied by a purchase order or a check. Checks should be payable to the Minnesota Ground Water Association. All materials should be sent to the Editor:

Lee Trotta
Editor, MGWA Newsletter
U.S. Geological Survey
702 Post Office Building
St. Paul, MN 55101

Congress Interested in Water Resources

by E.G. Newton, Washington Representative of AIPG.
Reprinted from "The Professional Geologist", November, 1989

House and Senate joint resolutions have been proposed to Congress for designating 1992 as the Year of Clean Water and October 1992 as Clean Water Month. The resolutions are in honor of the federal Clean Water Act, which was passed in October 1972. In other efforts to focus attention on water issues, resolutions from both houses of Congress call for President Bush to convene a White House water resources conference.

Citing the inability of many rural water supply systems to fund needed upgrading of their facilities, Senate bill 1296 proposes the establishment of a Rural Water Supply Assistance Program. This program would provide grants to states to set up revolving funds to finance the improvement, renewal, rehabilitation, repair, and modernization of rural water supply systems.

A number of bills aimed at helping farmers protect surface and ground water have been introduced. S.779 would establish a national educational program to encourage farmers to reduce nitrogen pollution of waters through the use of best management practices. The Farm Conservation and Water Protection Act of 1989, S.970, would promote low-input agricultural production systems while maintaining profitability and encourage land, resources, and wildlife stewardship in connection with federal farm programs. Title II of this bill encourages the restoration of converted wetlands and the protection of cropped wetlands.

The North American Wetlands Conservation Act, S.804 stresses preserving wetland ecosystems in order to protect fish, wildlife, and migratory birds that depend on them. H.R.1746, the Wetlands No Net Loss Act, would promote conservation and enhancement of wetlands.

H.R.2903 would decrease financial responsibilities for owners and operators of small businesses that use underground storage tanks. A similar bill, S.1560, is pending in the Senate. According to the sponsors of these bills, many small gas stations will go out of businesses if they can't obtain or afford the \$1,000,000 insurance coverage currently required. S.1560 would reduce the mandatory level of insurance to \$500,000, give gas station owners a 12-month extension in meeting insurance requirements, and require the U.S. Environmental Protection Agency to investigate affordable insurance.

A variety of ground-water bills have been introduced. Among them are H.R. 2734, The National Groundwater Research Act of 1989; S.362, a bill to promote intergovernmental and interagency cooperation in the development of ground-water policy; and S.397, a bill to provide assistance to small communities with ground-water radium contamination.

Copies of House bills can be obtained from the House Document Room, H-226 Capitol, Washington, D.C. 20515; Senate bills can be ordered from the Senate Document Room, SH-B 04, Washington D.C. 20510. Orders must include a self-addressed label and be limited to six items per day.

1990 Dues

Your MGWA member dues for 1990 are now needed. We are happy to report that dues have been kept at the same bargain rate of \$10.00 (or \$5.00 for current students). These amounts have remained unchanged since MGWA was founded, and we do anticipate a small increase for next year. If you have not paid 1990 dues, a yellow insert and return envelope is enclosed. **Please act now** to renew your membership.

If the enclosures were lost in the shuffle, please send a check made out to MGWA to:

Don Jakes, MGWA Treasurer
943 Lydia Drive
Roseville, MN 55113

Darcy Lecturer Invited to Minnesota

The AGWSE (Association for Ground Water Scientists and Engineers, an affiliate of the National Water Well Association) Board of Directors has announced that Ralph C. Heath is the Fourth Henry Darcy Lecturer. Heath will serve as a visiting lecturer to approximately 12 universities in North America with AGWSE subsidizing the travel expenses of the program. MGWA has invited Heath to speak in Minnesota. This prestigious program honors Henry Darcy's 1856 discovery of the basic law governing ground water flow.

Ralph Heath received a B.S. in geology from the University of North Carolina at Chapel Hill in 1948. He spent the next 34 years working for the USGS Water Resources, first as a ground water geologist in Florida where he worked on projects both in the western panhandle and in the central peninsula. He moved from Tallahassee to Albany in 1955 as geologist in charge of Upstate New York Ground Water Program. He later served as district geologist for New York and Southern New England and from 1965 to 1967, as the first district chief in charge of USGS water-resources studies in New York. In 1967, he transferred to Raleigh as district chief of his home state of North Carolina, a position he held until his appointment as staff hydrologist in 1981.

As a supervisor, Heath maintained close contact with project leaders, devoted considerable effort to the training of his technical staff, and also spent a significant amount of time on his own research projects. His research interests include the fluctuations of subsurface temperature, design of water level observation well programs, classification of ground water systems, and hydraulic characteristics of fractured rocks. He is experienced in ground water terranes from the carbonate rocks of Florida to the

Continued on next page...

glacial deposits of New York and New England, and in the Piedmont and Coastal Plain regions of North Carolina.

As a staff hydrologist of the USGS, he prepared Water-Supply Papers on *Basic Ground Water Hydrology* and *Ground Water Regions of the United States*, both of which are widely used as texts or references in ground water hydrology courses. He is also the coauthor of *Introduction to Ground-Water Hydrology*, which is used as a text in introductory ground water courses. Most recently, he prepared an article on the hydrogeologic setting of North American ground water regions and surficial and bedrock hydrogeologic maps of North America for the hydrogeology volume of the Geological Society of America's project on The Geology of North America.

Since 1986, Heath has practiced as a self-employed consulting hydrogeologist and in this new career has been involved in projects ranging from ground water pollution caused by powerplant ash ponds to determining the yield of the unconfined aquifer at Cape Hatteras, North Carolina. He also holds the position of lecturer at Duke University where he teaches both regular and intensive courses in basic ground water hydrology.

Heath has continued to write articles of broad interest to hydrogeologists, including one with Jay Lehr titled *A new approach to the Disposal of Solid Hazardous Waste*, which forms the basis of his Darcy lecture.

The title of Ralph Heath's lecture is **Hydrogeology and Hazardous Waste Disposal**. Topics covered in the lecture will include engineered solutions to waste disposal and a discussion of the hydrogeological features, which, if properly considered and utilized, may help avoid the problems that have resulted from past disposal practices.

Should Heath accept our invitation, notice of the meeting date and place will be given in a separate mailing as soon as they are determined.

Bay West Opens Environmental Lab

Bay West has opened an analytical laboratory at its headquarters in St. Paul this fall. The 4,000 square foot laboratory was custom built for environmental and industrial hygiene analytical services.

Bay West has also added new staff:

Dr. Thomas N. Tweeten is the Director of Analytical Services. He has more than 20 years of experience in analytical chemistry, including senior scientist at Pillsbury, technical director of Polymer Laboratories, Inc., and project leader and chemist for Hewlett-Packard.

Grant Paul, Analytical Chemist/Project Manager, is responsible for implementing methodology for analysis of organic compounds. He has 14 years of experience with analytical systems such as gas chromatography, GC/mass spectrometry, and high performance liquid chromatography. Before joining Bay West, he was an environmental analyst/supervisor for the Minnesota Department of Health.

Kathleen M. Palony, Senior Chemical Technician, has responsibility for organic and industrial hygiene analyses. She previously was a senior chemical technician for St. Paul Fire and Marine Insurance Company.

Richard Sinn, Analytical Chemist/Project Manager, is responsible for implementing analytical procedures for inorganic analysis. He was an environmental analyst/supervisor for the Minnesota Department of Health. He also worked for the Minnesota Pollution Control Agency and U.S. Environmental Protection Agency.

Luke E. Charpentier, Chemist, is responsible for samples that require inorganic analysis and maintaining the laboratory data management system. He was a laboratory technician at Cargill before joining Bay West.

Bay West is a 15-year old Minnesota corporation that provides

consulting, analytical testing and field services to industrial, commercial and governmental clients. Services include environmental compliance and hazardous waste management, industrial hygiene, ground water and engineering, analytical laboratory testing, and emergency response.

Bay West is located at 5 Empire Drive, St. Paul, Minnesota, 55103.

1990 Board of Directors

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1990 Membership Directory

Due to the growth of our membership to more than 500 professionals and students, it is no longer practical to publish our membership roster as part of the newsletter. The 1990 Membership Directory will be published as a separate handbook.

In addition to the names, addresses, and work phone numbers of all current MGWA members, it will include lists of contacts for information about state and federal regulatory programs, alphabetical and specialty listings of Minnesota groundwater businesses, and useful ground water trivia. (We will also add blank address pages so you can keep your own scores in the ground water job shuffle and PCA phone number lottery.)

This directory will be a reference you will use all year. It will be published in March as soon as most of the dues and address changes are received. The deadline for receipt of advertising copy is February 15, 1990. Current advertisers who want to use the same ad in the directory do not need to resubmit the copy.

Directory Advertising Rates

These rates are different from newsletter advertising rates which appear on page 9 of this issue. These rates apply only to the annual directory:

Size	inches	Rate
business card	3.5x2.4	\$35
quarter page	3.5x5	\$75
half page	7x5	\$140
full page	7x10	\$270
back inside cover	7x10	\$300

Camera-ready copy or high contrast business cards should be sent with payment to:

Watershed Research, Inc.
4779 126th Street North
White Bear Lake, MN 55110-5910.

Checks should be made out to MGWA.

Listing of Businesses

All companies, regardless of type of business, which have MGWA members will be listed in the business section of the directory. Other companies in the groundwater business which have no current MGWA members will be contacted to make them aware of this benefit of MGWA membership.

Services Listing

Consulting firms, suppliers, and drillers are invited to list their product categories or types of services in the directory. Each firm can supply up to six 'keywords' for the types of services they offer. The names of all firms submitting a given keyword will be listed alphabetically under that heading. We will most likely have to merge some categories with similar keywords. These keywords should be sent on company letterhead to the above address by February 15, 1990. Ask your company's public relations contact to send the chosen keyword for your firm now!

Corrections and Option not to be Listed

If you would prefer not to be listed in the Directory, or if your current MGWA mailing address is a home address and you'd prefer that the home address or phone number not be printed, please send the correct directory listing (and whether or not you want to change where the newsletter is sent) to the address above.

Spring Meeting March 8

Project Management Workshop

On **March 8, 1990** the Association for Women Geoscientists and MGWA will cosponsor an afternoon workshop (12:30 - 5:00) on project management. Most ground water professionals have never had a chance at formal training in the skills needed for efficient and effective project management. This workshop will give all project managers and project manager supervisors a chance to learn new skills and refresh old ones. The workshop will be held at the Earle Brown Center on the St. Paul Campus of the University of Minnesota.

The current list of topics includes:

- principles of project management
- systems planning and tracking,
- how to run productive project meetings
- delegation and motivation
- trouble shooting; spot problems and deal with them before it's too late
- identify strengths and weaknesses in staff members and use that knowledge to build an effective team
- resource management,
- time management,
- budget control, and
- communication and support building with management and staff.

Exhibitors of project management software, books, and training materials will be invited to display their wares during breaks.

The cost of this workshop is \$60 per MGWA or AWG member, \$75 for nonmembers, and \$20 for students.

Attendance will be limited due to the size of the room. Register as soon as possible to ensure that you will have a space.

Registrations may be sent to:

Don Jakes
MGWA Treasurer
943 Lydia Drive
Roseville, MN 55113.

MGWA Held Successful Fall Conference

The Minnesota Ground Water Association and the Minnesota Section of the American Water Resources Association (AWRA) held a joint fall meeting November 1, 1989, on the St. Paul Campus of the University of Minnesota. The topic was the Minnesota Ground Water Protection Act which was passed this past legislative session.

Speakers presented the legislation from the perspective of their various state agencies and departments. **Judith Ball**, Minnesota Department of Health, **Pat Bloomgren**, Board of Water and Soil Resources, **Greg Buzicky**, Minnesota Department of Agriculture, **Don Jakes**, Minnesota Pollution Control Agency, and **Ron Nargang**, Minnesota Department of Natural Resources, Division of Waters presented their explanations of the legislation and their ideas about how the different parts of the Act will be implemented.

Approximately 125 were in attendance and many remained after the close of the technical program for the award ceremony.

Congratulations to the **St. Anthony Falls Hydraulic Laboratory** on receiving the American Water Resources Association's Outstanding Water Resources Achievement Award. The Award was given to the Lab in recognition of its 50 years of research, education and service in the field of water resources.

Heinz Stefan, Acting Director of SAFHL, accepted the award on behalf of the faculty, staff and students of the Lab. **Kenneth D. Reid**, AWRA's Executive Director, **Kenneth N. Brooks**, AWRA's North Central Director, and the local officers **George Carlson**, **Jeanette Leete**, and **Cecilio Olivier** presented the Lab with a bronze plaque which will be mounted at the entrance to the facility.

Meeting Calendar

January 17, 1990. Minnesota Environmental Health Association: 1990 Winter Education Conference. To be held at the Sheraton Midway. Contact Gail Trenholm at (612) 939-8200 with any questions.

January 29 - 30, 1990. Minnesota Water Well Association 68th Annual Convention to be held in Minnetonka. Contact (612) 290-2823.

February 1 - 3, 1990. International Symposium on Borehole Geophysics for Petroleum, Hydrogeology, Mining, and Engineering Applications. To be held in Tucson, Arizona. Contact: Department of Mining and Geological Engineering, University of Arizona, Tucson, Arizona 85721.

February 19 - 23, 1990. International Symposium on Radon and Radon Reduction Technology. To be held in Atlanta, Georgia. Sponsored by the USEPA, Office of

Radiation Programs, EPA, 401 M Street, SW, Washington DC 20460.

February 20-22, 1990. Four conferences to be held under one roof: *Agricultural Impacts on Ground Water Quality, Ground Water Geochemistry, Ground Water Management and Well Head Protection, Environmental Site Assessments: Case Studies and Strategies.* To be held in Kansas City by NWWA.

February 26 - 27, 1990. Colorado Groundwater Engineering and Management Conference. To be held in Denver, Colorado. Contact: Water Resources Research Institute, Colorado State University, Fort Collins, CO 80523.

March 8 - 9, 1990. Water Resources Restoration and Remediation: The Wisconsin Experience. To be held at the Holiday Inn in Stevens Point, Wisconsin by the Wisconsin Section of AWRA, the U of Wisconsin-Stevens Point, and UW-Madison Water Resources Center.

March 12 - 16, 1990. Minimizing Risk in the Hydrologic Environment. To be held in Las Vegas, Nevada. Contact AIH at 3416 University Ave. SE, Minneapolis, MN 55414.

March 28 - 30, 1990. Upper Midwest Water Well Exposition. To be held in St. Charles, Illinois, by NWWA.

April 1 - 5, 1990. International and Transboundary Water Resources Issues - a joint meeting of the American and Canadian Water Resources Associations. To be held in Toronto, Canada. Ground water use, recycling, and disposal are among the topics. Contact AWRA at (301) 493-8600.

April 9 - 10, 1990. Minnesota Water: 1990. To be held at the Radisson Hotel, St. Paul by the Water Resources Research Center, University of Minnesota.

May 14 - 17, 1990. Fourth National Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring and Geophysical Methods. To be held at the Las Vegas Hilton in Las Vegas, Nevada by NWWA.

June 4 - 5, 1990. Annual Meeting of the Minnesota GIS/LIS Consortium. To be held at the Radisson St. Paul. Contact Les Maki at (612) 297-3417.

June 12 - 14, 1990. AGU Chapman Conference on Hydrologic Aspects of Global Climate Change. To be held at Lake Chelan, Washington. Contact AGU at (202) 462-6900.

June 18 - 21, 1990. USA/USSR Joint Conference on Environmental Hydrology and Hydrogeology. To be held in Leningrad, USSR. Contact Dr. Roman Kanivetsky, Minnesota Geological Survey, 2642 University Ave., St. Paul, MN 55114, or AIH at (612) 379-1030.

July 9 - 11, 1990. Watershed Management Symposium. To be held in Durango, Colorado. Contact Robert Riggins, USACERL,

continued on following page....

P.O. Box 4005, Champaign, Illinois 61824-4005.

July 9 - 13, 1990. National Conference on Irrigation and Drainage. To be held in Durango, Colorado. Contact Robert Riggins, USACERL, P.O. Box 4005, Champaign, Illinois 61824-4005.

July 23 - 27, 1990. International Symposium on Tropical Hydrology and Fourth Caribbean Islands Water Resources Congress. To be held in San Juan, Puerto Rico. Contact: Dr. Munoz-Candelario, Water Resources Research Institute, University of Puerto Rico, Mayaguez Campus, PO Box 5000, Mayaguez, Puerto Rico.

August 11 - 16, 1990. Annual URISA Conference: Information, the Currency of the Future. Topics include Geographic Information Systems, Land Records, AI/Expert Systems. To be held in Edmonton, Alberta, Canada. Contact URISA, 900 Second St. NE, Suite 304, Washington, DC 20002 (202) 289-1685.

August 12 - 15, 1990. Conserv 90. A National Conference and Exposition Focusing on Water Supply Solutions for the 1990s. To be held in Phoenix, Arizona by NWWA.

September 3 - 6, 1990. International Conference on Calibration and Reliability in Ground Water Modeling. To be held in The Hague. Contact NWWA.

September 11 - 14, 1990. Gas Transfer at Water Surfaces. To be held in Minneapolis, Minnesota. Contact Steven Wilhelms, U.S. Army Engineer Waterways Experiment Station, P.O. Box 631 Vicksburg MS 39180 (601 634-2475).

September 18 - 20, 1990. 5th Canadian/American Conference on Hydrogeology: Parameter Identification and Estimation for Aquifer and Reservoir Characterization. To be held in Calgary, Alberta, Canada.

November 5 - 9, 1990. 26th Annual AWRA Conference - "The

Science of Water Resources: 1990 and Beyond", "Symposium - Transferring Models to Users". Contact AWRA at (301) 493-8600. Deadline for abstracts November 1, 1989.

November 5 - 7, 1990. International Conference on Groundwater Resources Management. To be held in Bangkok, Thailand. Contact: The Secretariat, International Conference on Groundwater Resources Management, Division of Water Resources Engineering, Asian Institute of Technology, PO Box 2754, Bangkok 10501 Thailand.

For information about meetings and seminars to be held by the NWWA, contact NWWA at 6375 Riverside Drive, Dublin, Ohio 43017 (614) 761-1711, Telex 241302.

Short Course Calendar

January 22 - 24, 1990. Treatment Technology for Contaminated Ground Water. To be held at the Orlando Marriott in Orlando, Florida by NWWA.

January 22 - 24, 1990. Critical Issues in Underground Storage Tank Management - Focuses on new EPA requirements. To be held at the Orlando Marriott in Orlando, Florida by NWWA.

January 25, 1990. One-Day Site Assessment Course. To be held at the Orlando Marriott in Orlando, Florida by NWWA.

January 30 - 31, 1990. Underground Storage Tanks: Smart Management & Engineering Ap-

continued on following page....

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In St. Paul, ask for:

Wes Vossler

Al Smith

Vince Lewis

plications. To be held in Denver, Colorado by Government Institutes, Inc. 966 Hungerford Drive #24, Rockville Maryland 20850 (301) 251-9250.

January 29 - February 2, 1990.

The Princeton Course - Groundwater Pollution and Hydrology - Comprehensively covers all aspects of groundwater pollution and hydrology from theory to practice. To be held in Princeton, New Jersey. Contact Groundwater Associates of Princeton, Omni Environmental Corporation, Three Independence Way, Princeton, New Jersey 08540.

February 1 - 2, 1990. *The Fundamentals of Ground Water Contamination.* To be held at the Cathedral Hill Hotel, San Francisco. Contact: R. M. Miller, American Ecology Services, Inc., 127 East 59th Street, New York, New York 10022 (212) 371-1620.

February 6 - 8, 1990. *Principles of Ground Water Hydrology.* To be held at the Stouffer Concourse Hotel in Denver, Colorado by NWWA.

February 6 - 8, 1990. *Corrective Action for Containing and Controlling Ground Water Contamination.* To be held at the Stouffer Concourse Hotel in Denver, Colorado by NWWA.

February 6 - 8, 1990. *Theory and Application of Borehole Geophysics to Ground Water Problems.* To be held at the Stouffer Concourse Hotel in Denver, Colorado by NWWA.

February 9, 1990. *DRASTIC Workshop.* To be held at the Stouffer Concourse Hotel in Denver, Colorado by NWWA.

February 12 - 16, 1990. *The Princeton Course - Groundwater Pollution and Hydrology - Comprehensively covers all aspects of groundwater pollution and hydrology from theory to practice.* To be held in San Francisco, California. Contact Groundwater Associates of Princeton, Omni Environmental Corporation, Three Independence

Way, Princeton, New Jersey 08540.

February 13 - 14, 1990.

Workshop on Application of Remote Sensing in Hydrology. To be held in Saskatoon, Saskatchewan, Canada. Sponsored by the Scientific Information Division, National Hydrology Research Institute, 11 Innovation Blvd., Saskatoon, Saskatchewan S7N 2H5 Canada.

February 19 - 23, 1990. *Introduction to Ground Water Modeling.* To be held by the IGWMC in Indianapolis, Indiana.

March 12 - 14, 1990. *Characterization and Modeling of the Vadose Zone: Measurement and Prediction.* To be held at the University of Arizona at Tucson. Contact Dr. Peter J. Wierenga, Department of Soil and Water Science, University of Arizona, Tucson, AZ 85721; (602) 621-7228.

March 19 - 22, 1990. *Analysis and Design of Aquifer Tests.* To be held at the Hyatt Regency Ohio Center in Columbus, Ohio by NWWA.

March 19 - 23, 1990. *Applied Ground Water Modeling.* To be held by the IGWMC in Indianapolis, Indiana.

March 20 - 22, 1990. *Introduction to Ground Water Geochemistry.* To be held at the Hyatt Regency Ohio Center in Columbus, Ohio by NWWA.

March 21 - 22, 1990. *Applied Drilling Engineering for Rotary and Auger Methods (for ground water-related investigations).* To be held at the Hyatt Regency Ohio Center in Columbus, Ohio by NWWA.

April 16 - 19, 1990. *The Use of MODFLOW for Analysis of Ground Water Flow Systems.* To be held at the Chicago Hilton & Towers, Chicago, Illinois by NWWA.

April 17 - 19, 1990. *Theory and Application of Vadose Zone Monitoring, Sampling, and*

Remediation. To be held at the Chicago Hilton & Towers, Chicago, Illinois by NWWA.

April 18 - 19, 1990. *Environmental Site Assessments in Conjunction with Real Estate Transactions Two-Day Course.* To be held at the Chicago Hilton & Towers, Chicago, Illinois by NWWA.

May 1 - 3, 1990. *Critical Issues in Underground Storage Tank Management - Focuses on new EPA requirements.* To be held at the Baltimore Marriott Inner Harbor in Baltimore, Maryland by NWWA.

May 4, 1990. *Environmental Site Assessments One-Day Course.* To be held at the Baltimore Marriott Inner Harbor in Baltimore, Maryland by NWWA.

May 1 - 3, 1990. *Principles of Ground Water Hydrology.* To be held at the Baltimore Marriott Inner Harbor in Baltimore, Maryland by NWWA.

May 4, 1990. *Environmental Site Assessments One-Day Course.* To be held at the Baltimore Marriott Inner Harbor in Baltimore, Maryland by NWWA.

June 5 - 7, 1990. *Theory and Practice of Ground Water Monitoring and Sampling - Designed for Newly Practicing Professionals.* To be held at the Westin Hotel in Cincinnati, Ohio by NWWA.

June 7 - 8, 1990. *Environmental Site Assessments in Conjunction with Real Estate Transactions - Two Day Course.* To be held at the Westin Hotel in Cincinnati, Ohio by NWWA.

June 12 - 14, 1990. *Introduction to Ground Water Geochemistry.* To be held at the Sir Francis Drake Hotel in San Francisco, California by NWWA.

June 12 - 14, 1990. *Applications of Environmental Isotopes to Practical Ground Water Studies.* To be held at the Sir Francis Drake Hotel in San Francisco, California by NWWA.

continued on following page....

Short Courses Continued

July 17 - 19, 1990. *Principles of Ground Water Hydrology.* To be held at the Red Lion Inn, Jantzen Beach, Portland, Oregon by NWWA.

July 20, 1990. *Environmental Site Assessments One-Day Course.* To be held at the Red Lion Inn, Jantzen Beach, Portland, Oregon by NWWA.

July 23 - 27, 1990. *Optimization and Risk.* To be held by the IGWMC in Indianapolis, Indiana.

July 30 - August 3, 1990. *ASCE Hydraulics Division: 1990 National Conference on Hydraulic Engineering and The International Symposium on the Hydraulics/Hydrology of Arid Lands.* To be held at the

Water Resources Education Materials

The AWRA Education Committee is trying to gather up as much water resources teaching material as possible. They are primarily interested in grades K - 12, but they admit they'll take anything K through death. Please send copies of anything available for free to: Richard A. Herbert, c/o AWRA, 5410 Grosvenor Lane, Suite 220, Bethesda, Maryland 20814-2192.

Catamaran Hotel, San Diego, California.

August 7 - 9, 1990. *Critical Issues in Underground Storage Tank Management - Focuses on new EPA requirements.* To be held at the Dallas Sheraton in Dallas, Texas by NWWA.

August 12 - 17, 1990. *IBM PC Applications in Ground Water Pollution and Hydrology: A Hands-on Short Course.* To be held at the Nassau Inn at Palmer Square, Princeton, New Jersey by NWWA.

September 17 - 19, 1990. *Introduction to Ground Water Geochemistry.* To be held at the Radisson Hotel in Toronto, Canada by NWWA.

September 24 - 28. *Incremental Flow Modeling.* To be held by the IGWMC in Indianapolis, Indiana.

October 1 - 3, 1990. *Theory and Practice of Ground Water Monitoring and Sampling - Designed for Newly Practicing Professionals.* To be held at the Ramada Renaissance Hotel in Long Beach, California by NWWA.

October 4, 1990. *Environmental Site Assessments One-Day Course.* To be held at the Ramada Renaissance Hotel in Long Beach, California by NWWA.

October 15 - 19, 1990. *Multi-phase Organic Transport Modeling with Emphasis on Pollution by*

Hydrocarbons. To be held by the IGWMC in Indianapolis, Indiana.

October 23 - 25, 1990. *A Comprehensive Approach to Development and Protection of Ground Water Supplies.* To be held at the Sheraton Palace Hotel in San Francisco, California by NWWA.

October 24 - 25, 1990. *Applied Drilling Engineering for Rotary and Auger Methods (for ground water-related investigations).* To be held at the Sheraton Palace Hotel in San Francisco, California by NWWA.

November 6 - 8, 1990. *Critical Issues in Underground Storage Tank Management - Focuses on new EPA requirements.* To be held at Bally's Las Vegas in Las Vegas, Nevada by NWWA.

November 6 - 8, 1990. *Theory and Application of Vadose Zone Monitoring, Sampling, and Remediation.* To be held at Bally's Las Vegas in Las Vegas, Nevada by NWWA.

November 9, 1990. *Legal Implications of Environmental Site Assessments.* To be held at Bally's Las Vegas in Las Vegas, Nevada by NWWA.

December 3 - 5, 1990. *Principles of Ground Water Hydrology.* To be held at the Columbus Marriott North, Columbus Ohio by NWWA.

Join the Minnesota Ground Water Association!

If you are reading this newsletter second-hand, we'd like to take this opportunity to invite you to become a member of MGWA. Annual dues are \$10 for professional members and \$5 for students.

Just complete the form below and mail to: Minnesota Ground Water Association, c/o Don Jakes, 943 Lydia Drive, Roseville, MN 55113

Name _____
Affiliation _____
Mailing Address _____
City, State, Zip Code _____
Telephone Number _____
Address for Directory Listing _____
Telephone Number for Directory Listing _____

December 3 - 5, 1990. Fundamentals of Ground Water and Well Technology. To be held at the Marriott Inn North, Columbus Ohio by NWWA.

For information about courses held by NWWA, contact NWWA at 6375 Riverside Drive, Dublin, Ohio 43017 (614) 761-1711, Telex 241302.

For information about Short Courses held by International Ground Water Modeling Center (IGWMC), contact the IGWMC, Holcomb Research Institute, Butler University, Indianapolis, IN 46208 (317) 283-9458.

Internship Opportunities Sought

Students from Minnesota Colleges and Universities are seeking paid and unpaid internship opportunities for a semester or for the school year. MGWA has received inquiries from students who would like to work in the environmental and geology fields.

If you can employ an intern or provide an educational opportunity for a volunteer, or if you are a student who wants to get experience, please send a description of the position (or your resume) to Dr. Jeanette Leete at the DNR - Division of Waters, 500 Lafayette Road, St. Paul, MN 55155-4032.

Help Direct GSA's Future

The Geological Society of America (GSA) Committee on Nominations requests your help in compiling a list of GSA members qualified for service as officers and councilors of the Society. The committee requests that each nomination be accompanied by basic data and a description of the qualifications of the individual for the position recommended (vice-president, treasurer, Councilor). Please send nominations and backup material to: Administrative Department, GSA, P.O. Box 9140 Boulder, CO 80301.

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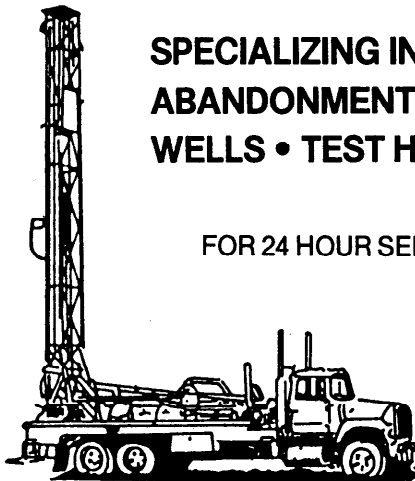


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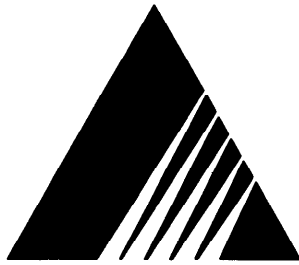
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March 8, 1990: Project Management Workshop

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