Minnesota Ground Water Association

Volume 15, Number 1: March, 1996

President's Column

Greetings! This is my first column as president of the Minnesota Ground Water Association, a responsibility I take seriously and with some trepidation. I've been a member of MGWA since it was formed, and was treasurer of the organization in the early 80's. We have grown and developed since that time, building on the increasing awareness of ground water both in the public mind and in regulatory and cleanup programs at all levels of government. I believe in the mission of this organization, have participated in its history, and look forward with confidence to a bright future for the MGWA.

What's Planned for 1996?

Change of tax status is something we are working on this year. We are currently incorporated as a non-profit organization, but are seeking to change our status to that of a 501(c)(3) organization, which would make our dues and other donations deductible. In 1995, changes were incorporated in our money management procedures to allow for this. Jeanette Leete, through her company Watershed Research Incorporated, has been and will be instrumental in helping the organization make some of these changes. The MGWA also contributes moderate sums of money to various worthy ground water related causes. The Board will be discussing the giving plan for 1996 at our March 7 meeting, and finalizing decisions on this April 4th.

We will be offering a solid slate of programs, with a spring policy-oriented meeting, a fall technical workshop, a fall field trip in conjunction with AIPG, and perhaps even a summer picnic to celebrate our fifteenth year of incorporation. Another event happening in

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MPCA Adopts New Rules for Individual Sewage Treatment Systems

—**Gretchen Sabel**, *Supervisor, Individual Sewage Treatment Systems Unit, Minnesota Pollution Control Agency*

On January 23, 1996, major revisions to Minnesota Rules Chapter 7080 went into effect. The revamped rule strengthens the requirements for construction of Individual Sewage Treatment Systems (ISTS), more commonly known as septic systems. There are three parts to the rules: technical standards for construction, registration and licensing requirements for persons working on ISTS, and administrative requirements for local governments which regulate ISTS.

Legislation passed in 1994 set the stage for these changes. Before this law, codifed as Minnesota Statutes Chapter 115.55, was enacted, regulation of ISTS in Minnesota was a patchwork of local programs and requirements. MPCA wrote a rule which set technical standards for ISTS construction, but local governments were free to decide which provisions, if any, they would adopt and enforce. The 1994 law required that all ISTS ordinances enacted by local government be in compliance with MPCA's ISTS rules by January 1, 1996. (That deadline was extended to January 1, 1998, in the 1995 legislative session.) Local governments still may choose not to regulate ISTS, in those areas the MPCA is responsible for ensuring that ISTS standards are met.

Other provisions of the law include requirements for "disclosure" of ISTS status at time of property transfer and upgrade of non-conforming ISTS before permits for bedroom or bathroom additions are granted.

Ground water protection and the protection of public health are key features of the ISTS rule. Sewage is treated in an ISTS both within the septic tank and in the soil underlying the soil treatment system.

The rules require a three-foot separation between the bottom of the soil treatment system and the uppermost seasonally-saturated soil. Mottling of the soil is used as an identifying characteristic of seasonal saturation.

A three-foot separation to bedrock is also required, which can be a problem in shallow bedrock areas of the state. An ISTS can provide a high degree of treatment if designed, constructed and maintained properly. The ISTS treats sewage in biological, physical and chemical processes. An ISTS typically consists of a septic tank and some type of a soil treatment system, such as mound, trench or at-grade: The type of soil treatment system depends on local soil conditions.

Raw sewage leaves the home and enters a watertight septic tank where it stays for about 36 hours. Detention time allows the physical process of settling solids, floating greases and fats.

Anaerobic bacteria inside the tank begin the biological process of

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The primary objectives of the MGWA are:

- Promotion and encouragement of the scientific and public policy aspects of ground water;
- Establishment of a common forum for scientists, engineers, planners, educators, attorneys, and other persons concerned with ground water;
- Education of the general public regarding ground water resources; and
- Dissemination of information on ground water.

President's letter, cont.

1996 is the fall conference of the Ground Water Protection Council, a national organization of ground water program managers with emphasis on wellhead protection and underground injection control. The talks offered here will be of interest to our membership as well-consider offering a paper yourself. The call for papers is reprinted in this newsletter on page 6.

Speaking of meetings, our Spring Meeting will be held on April 25, titled **Ground Water Management, Wellhead Protection and Beyond**. We are inviting speakers to represent various levels of local government who have met and overcome serious ground water related problems, from the threat of development pressures in Karst terrain, to coordinating smaller jurisdictions to address regional problems, to areas where water availability is a key factor in regional growth patterns. This meeting will be of interest to local resource managers, state regulatory and assistance personnel, and the consultants who provide technical expertise. There is more detail on page 4.

Welcome New Board Members!

We have new board members to welcome as well. Ray Wuolo from Barr Engineering is our new President-elect, and will step into the President spot in 1997. Jan Falteisek (Minnesota Department of Natural Resources, Division of Waters) has won a two-year term as Secretary, and is handing over the job of Advertising Manager to Jim Almendinger (St. Croix Watershed Research Station). Look for biographical sketches introducing the new board members on page 5. Welcome to all. It is sure to be an interesting and challenging year.

Student Referral Service

As a service to our members, the MGWA will experiment with offering a student referral service. Member students who wish to participate may submit a copy of their resume to the MGWA at the St. Paul address. Submitted resumes will be then made available to those wishing to hire student workers in ground water related jobs, such as summer sampling help with state agencies and student interns in consulting companies. Resumes will only be accepted from students who are members in good standing (that means you've paid the yearly dues), and will be kept on file for a year unless the student requests to be taken out of the system earlier. Potential employers should submit written requests for resumes also to the St. Paul address.

MGWA Needs You!

The MGWA lives on the strength of its membership. Now would be a great time to take a more active role in the organization, perhaps by helping with meeting planning, contributing to our quarterly newsletter, or in some other role. The doors are always open to willing volunteers.

Individual Sewage Treatment, cont.

breaking down the organic matter in sewage.

Sewage Treatment 101:

The soil treatment system: The soil treatment system is designed to create suitable conditions for further treatment. It consists of a piping network and some type of distribution medium (rock, sand, or manufactured media). The design considers the volume of septic tank effluent, the type of soil accepting the effluent and relies on the development of a "biomat."

The biomat: As sewage tank effluent flows into a soil treatment system, it moves out the distribution pipe and down through the rock to the rock/soil interface. A biological layer (biomat) is formed by microorganisms that secrete a sticky substance and anchor themselves to the soil/rock interface. This biomat forms first along the trench bottom, and as liquid begins to pond in the trench, it forms along the soil surfaces on the trench sidewalls. The biomat is formed only under aerobic conditions and provides additional removal of bacteria and solids.

The biomat acts as a valve to slow the effluent flow into the soil. It creates "trickle" flow to the soil beneath the biomat. The biomat can slow effluent movement to 100 times less than the saturated flow of the soil, allowing the soil to remain "unsaturated." Slowing effluent movement is necessary to maximize the contact time between the effluent and the soil particles in the unsaturated zone.

A mature soil treatment system will have effluent ponded in the trench while the soil a few inches outside of and below the trench will be unsaturated. Unsaturated means the soil has pores containing air (aerobic). This type of environment promotes further effluent treatment by aerobic bacteria.

How soil treats sewage: Septic tank effluent, slowed by the biomat, trickles through the soil and moves past air pockets and soil particles. The air pockets allow aerobic bacteria to continue treatment and are much more efficient than the anaerobic bacteria in the septic tank. The soil particles act as a magnet to adsorb pollutants and as a filter when biological slimes develop around the soil particles.

Soil particles act as magnets because they are negatively-charged particles. Bacteria and viruses are positively-charged and can be adsorbed onto the soil particles. Bacteria then grow on the nutrients, producing slimy films over the soil particles. The slime acts as a filter and grabs bacteria, viruses and other pollutants which will then die off because of exposure to changes in temperature and lack of moisture and food.

If the system bottom is located near the water table, contaminants can pollute the ground water because they

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Individual Sewage Treatment, cont.

move quickly though the soil without being adsorbed or filtered.

Several types of soil treatment systems are described in the rule as "standard systems". The key determinant in choosing the type of soil treatment system to use is the depth to the limiting conditions of mottling, bedrock or seasonally saturated soil. If the limiting condition lies more than five feet below the ground surface, conventional in-ground trenches (either gravel-filled or with drainfield pipe laid into the soil without gravel) may be used. In situations where this depth is less, other types of systems such as at-grades and mounds are appropriate. In an at-grade, the drainfield is constructed at the natural ground surface and then covered with soil. Mounds are built when the separation to limiting conditions is two feet or less. In these cases, sand is brought in to make up the difference to the three foot separation, and then the effluent distribution system (usually a pressurized piping system in a gravel media) is constructed over the sand. The entire mound is then covered with two feet of soil.

Conventional ISTS may contribute nitrate to the ground water, and so are potential sources of ground water contamination. Work is on-going through a grant from the Legislative Commission on Minnesota Resources to test advanced treatment technologies for ISTS under Minnesota weather conditions. The revised 7080 rule allows use of experimental technologies when monitoring of performance is conducted. Once proven effective, experimental technologies may be adopted into the rule as standard systems at later rule revisions.

Registration and licensing requirements are established in the rule for all who work in the ISTS field in Minnesota. The professional will indicate the ISTS specialty areas in which they wish to work: site evaluation and design, system installation, septic tank pumping or system inspection. Registration is the first step, where the ISTS professional attends training, passes tests and demonstrates specific experience in the field. Employees of local and state governments thus qualified can stop here; persons who work as ISTS contractors (site evaluators, designers, installers, inspectors and pumpers) must also be licensed by the MPCA. They must submit proof of insurance and a $10,000 bond and pay $100 per specialty area in order to be licensed.

All work done on ISTS in Minnesota after March 31, 1996, must be done by either a licensed business or a qualified government employee. All work must meet the technical standards of Minnesota Rule Chapter 7080. This is the real "teeth" in the law - if standards are not met, the MPCA has authority to restrict or revoke licenses. MPCA will not be regulating each individual ISTS out there, but will hold all who work in the field to the standards set in the rule.

The law does not allow persons with registration in seemingly-related fields to perform ISTS work without going through the MPCA registration and licensing program. This means that registered professional engineers and geologists still need to attend ISTS training, pass MPCA exams and provide documentation of experience to also be registered as ISTS professionals; those who work in the private sector must also purchase business licenses as described above. Course work and training obtained by persons in other fields may count toward ISTS training if needed areas are covered. MPCA is developing "need to know" criteria for each of the specialty areas to be used in evaluating the applicability of other course work and training to the ISTS requirements.

Local administration of ISTS programs will be the cornerstone of effective ISTS regulation in Minnesota. Many local governments were doing a good job of regulating ISTS in their jurisdictions. Minnesota Rules Chapter 7080 now has established standards for local programs and specifies administrative procedures for fulfilling statutory requirements.

The MPCA is looking forward to working with local jurisdictions in implementation of the program.

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Minnesota Water Line Gets Off the Ground

A growing concern for water quality and safe drinking water supplies underscores the need for practical education and access to information. For a citizen who wonders what the environmentally-friendly solution might be, the process of finding the necessary information can be confusing. During the development of county water plans, citizens had expressed concern about their ability to find accurate and trustworthy information on water quality (particularly related to their health), to understand complex environmental regulations, and to trace the involvement of a myriad of agencies.

The Minnesota Extension Service and the American Ground Water Trust worked together to initiate the Minnesota Water Line as a pilot project in eleven northeast and east-central Minnesota counties. The toll free information line at 1-800-455-4526 connects citizens and decision makers who have questions about water issues to professionals in the water quality industry. The mutually shared mission of the two partners is to educate and involve the citizens of Minnesota in managing and making decisions regarding the use of the state's water resources. As of November 1995, the Water Line can be reached by all citizens of Minnesota.

The Water Line coordinator receives calls and responds immediately to those inquires that can be answered briefly, such as how to get well water tested. Calls of a more complex nature are referred to volunteer technical advisors or appropriate local or state agency staff. The Water Line coordinator, together with volunteers and agency partners, provides technical information, suggests alternatives and consequences for action, and helps callers to identify and work with information resources at the local level.

The volunteer network of industry technical advisers are professionals such as hydrogeologists, engineers, well contractors, attorneys, and public agĉncy staff. They are selected and trained by a team from the two partner organizations. Training includes response protocol, risk communication skills, and statewide information resources. To volunteer for the Water Line, please contact Deanne Roquet at the phone number listed at the end of this article. The Water Line is currently in need of volunteers in the fields of well drilling and pump installing.

Over 150 citizens have contacted the Line for assistance since April. The majority of the calls received to date involved concerns with septic systems, well contamination, and well construction problems. The following table lists the different subjects of calls by percent of the total calls received.

Subjects of calls:	% of calls
Septic issues	25
Well contamination - Health hazard	23
Iron and sulfur bacteria	14
Well construction and regulations	9
Water testing	7
Water quality issues	7
Ponds	4
Water treatment - in home	2
Surface water drinking supplies	1
Other	9

Though our formal evaluation has not been completed, the response to the assistance provided has been very positive. Callers have phoned the Line to express their appreciation for the timely, helpful information received. The follow-up survey was mailed out in early February 1996.

A formal determination of the effectiveness of the Water Line will be based on:

- Number of calls received from citizens and decision makers;

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MGWA Spring Conference

As this issue goes to press, your board is busy planning the 1996 Spring Conference. This year, the conference will be an afternoon seminar entitled:

Applied Ground Water Management: Wellhead Protection and Beyond

The goal of the seminar is to share ideas about how local water resource managers are working to integrate various ground water protection and regulation programs at the local level to address specific issues. The program should be of special interest to those working for local governments, state -level regulators, and consultants working for local government in water supply, wellhead protection, and water resource planning.

Topic areas defined so far include:

- Planning/Intergovernmental Coordination
- Wellhead Protection Implementation
- Water Availability Issues in Growth
- Information Resources in Ground Water Protection

Although the final agenda has yet to be established, be sure to mark **April 25th at the Earle Brown Center** on your calendar. Watch for a registration form to come by mail later in March.

Individual Sewage Treatment, cont.

Future challenges will make that implementation very interesting. Compliance with ISTS standards of any vintage ranges widely across the state. In some areas many homes directly discharge septic tank effluent into tile lines and ditches. Seeping, weeping systems leaking sewage into backyards are all too common. The cost of installing good systems is high in the short run, but pays off in system longevity, reliable long-term operation and cleaner ground and surface water.

References: Sewage Treatment 101 extracted from the "Statement of Need and Reasonableness" prepared by MPCA in May, 1995, in support of amendments to Minnesota Rules Chapter 7080.

Minnesota Water Line, cont.

- A six month follow-up survey to identify changes in behavior, problem resolution, and/or cost savings as a result of information or assistance received.
- A reduction in the number of calls to cooperating state agencies or an increase in the properly directed calls to state and local agencies.
- Written case studies of problem resolution by citizens and/or communities and the volunteer professionals.

The Minnesota Water Line is funded through December 1996. The Water Line partners are seeking funds for continued operation of the Water Line. Strategies to market the service to other audiences, such as local officials, are being developed. The following counties have decided to join the partnership by contributing funding to the project:

Chisago
Dakota
Isanti
Marshall
St. Louis
Sibley
Steele

For more information contact:

Deanne Roquet
Water Line Coordinator
2305 East 5th Street
Duluth, MN 55812-1445
(218)728-5968
email:droquet@d.umn.edu

1995 GWMAP Report

MPCA's Ground Water Monitoring and Assessment Program (GWMAP) announces publication of its 1995 annual report on the status of the state's ground water quality. Results of 197 well samples from central Minnesota collected during the 1994 field season are presented, along with distribution maps for several parameters of concern including nitrate, boron, and arsenic. Also featured is a comparison of water quality in several of Minnesota's principal aquifers from 1985 versus quality in those same aquifers in 1994. Copies are available from MPCA at (612)296-7789.

New Additions to the 1996 MGWA Board

Ray W. Wuolo, President Elect: Ray Wuolo has been a hydrogeologist with Barr Engineering Company in Minneapolis since 1988. Prior to joining Barr, Ray worked for EWA, Inc. and the U.S. Geological Survey in Rapid City, SD. He received a BS in Geological Engineering from Michigan Tech in 1983 and an MS in Geological Engineering from South Dakota School of Mines in 1986. Ray is a Professional Engineer, Certified Professional Geologist, Certified Ground Water Professional, and a registered Professional Engineer in Wyoming. He is currently serving on the editorial board of the Journal of Ground Water. Ray's primary focus has been in the application of ground-water models to contamination, geotechnical, and water-resources problems.

Jan D. Falteisek, Secretary: Jan Falteisek is a hydrogeologist supervisor with the Minnesota Department of Natural Resources. She is presently technical supervisor for ground water and pollution sensitivity mapping efforts being conducted jointly with the Minnesota Geological Survey. Before joining the DNR in 1990, she worked at the Minnesota Pollution Control Agency on Superfund clean up projects for nearly six years. She has an undergraduate degree in mathematics from Southwest State and a Master's degree in geology specializing in hydrogeology from the University of Missouri. Jan was editor of the MGWA newsletter for four years, 1990-1994, and recently turned over the role of advertising support for the association to Jim Almendinger (below).

Jim Almendinger, Advertising Manager: Jim Almendinger received a BA in botany from Ohio Wesleyan University (1978), and a Ph.D. in ecology from the University of Minnesota (1988). His introduction to ground water came during graduate school, where he studied analytic-element flow modeling and applied this tool to infer relations between past lake levels, ground water, and climate. Several years of post-doctoral work in Alaska and Sweden involved further investigation of lake/ground-water interactions. For the past five years he has been a hydrologist with the US Geological Survey, working mostly on the ground-water hydrology of calcareous fens. He has recently accepted a position at the St. Croix Watershed Research Station under the aegis of the Science Museum of Minnesota. He has been a member of the Minnesota Ground Water Association since its inception.

Minnesota Water '96

Changing Patterns of Power and Responsibility: Implications for Water Policy

The 5th biennial conference on Minnesota's critical water resources issues
May 20 -21, 1996.
Minneapolis Convention Center

The theme of this year's conference is the shift of power from centralized authorities toward the "grass roots" (the so-called devolution of power) and the impacts this trend is having on water resources management, research, and education. Sessions will focus on changes at all levels of government, water education, monitoring and assessment programs, and citizen participation.

The conference is scheduled to begin Monday; May 20 at 8:30 am and conclude Tuesday, May 21 at 4:30 p.m. The registration fee of $90 will include admission to the sessions, lunches, refreshment breaks and a book of abstracts. A discounted registration fee will be available for students.

The Minneapolis Convention Center is located at 1301 2nd Avenue S., in the heart of the downtown Minneapolis, convenient to restaurants, entertainment and hotel accommodations. A block of rooms will be held for conference participants at The Regal Minneapolis Hotel, 1313 Nicollet Mall, across the street and connected by skyway to the Convention Center.

For further information, please contact the Water Resources Research Center at 1518 Cleveland Ave. N, Suite 302, University of Minnesota, St. Paul, MN, 55108 or call (612) 624-9282, fax (612) 625-1263, or e-mail juerg001@maroon.tc.umn.edu.

1996 International Ground Water, Source Water Protection and Underground Injection Control Stakeholders Conference and Symposium

—Reinventing and Streamlining Government Regulations and Forming Partnerships —

The Ground Water Protection Council and The U.S. Environmental Protection Agency, in Cooperation with other State and Federal Agencies, Local Governments and Citizen Groups will cosponsor the event scheduled for September 1996 in Minneapolis, MN. The conference will focus on practical approaches to ground water, wellhead/source water protection and underground injection control. We are accepting abstracts on the following topics for oral, poster presentation or panel discussions:

Wellhead and Source Water Protection

- Source water protection delineation methodology
- Status and trends of program implementation
- Wellhead/source water protection and the watershed approach
- Innovative approaches to focus prevention and corrective activities in source water and wellhead protection areas

Ground Water and Watersheds

- Ground water and watersheds
- How to include ground water in the watershed approach
- Ground water quality and quantity
- Comprehensive ground water protection programs as a component of watershed protection
- Ground water surface water interactions
- Ground water as a contributor to surface water contamination
- Role of GIS in watershed, source water and wellhead protection

Agricultural Activities and Ground Water Quality/Protection

- State regulations, BMP's and local ordinances
- Agricultural best management practices
- State management plans
- Contamination/cleanup
- Agricultural drainage wells
  -Status of national inventory
  -Contamination issues
  -BMP's

Stormwater

- Regulations, ordinances, best management practices
- Quality of stormwater
- Documentation of impacts on ground water from stormwater

Shallow Drain Wells (Injection Wells) - Division V

- Innovative solutions for dealing with Class V wells
- On-site sewage system
- Needed plumbing code revisions
- State implementation issues relating to EPA Class V regulations
- Septic Systems and the pending EPA Class V regulations

Federal, State, Local Role in Ground Water Protection

- Building partnerships
- Accepting responsibility
- Funding mechanisms

International Session

- Examples of innovative programs in place worldwide
- How to form and maintain international partnerships
- Technology exchange and the information superhighway

If you are interested in presenting a paper at this meeting, please submit an abstract to the Ground Water Protection Council, at 827 NW 63rd Street, Suite 103, Oklahoma City, OK 73116, by June 1, 1996. Be prepared to give a 20 minute presentation, followed by a 10-minute discussion period. All papers selected for oral presentation will be published in the conference proceedings. If you have questions, please call (405)848-0690.

The Effects of Air Sparging on Aquifer Hydraulic Conductivity

— Hans Neve, Hydrologist, Ground Water Unit, Minnesota Pollution Control Agency

Introduction

Air sparging is a remediation technique used to remove organic contaminants from aquifers. Under favorable geologic conditions it can be a very effective remediation technique for some types of contaminants. This technology involves injecting air into contaminated aquifers. Injected air can remove contaminants through volatilization and enhanced aerobic biodegradation. Volatile contaminants can partition from ground water into injected air and be transferred to the vadose zone where they can then be extracted more efficiently. Air sparging can also provide a source of oxygen to ground water enhancing aerobic biodegradation. Air sparging produces both physical and chemical changes in aquifers, many of which are poorly understood.

Air injected into an aquifer must occupy a portion of the available pore space. These air filled pore spaces cannot transmit significant amounts of water, hence the flow of water is restricted to the remaining water filled pores. Injected air that occupies a significant portion of the available pore space may cause a local zone of low hydraulic conductivity which may in turn change the direction and rate of ground water and contaminant movement. This study measures changes in hydraulic conductivity produced by air sparging.

Laboratory Test Experimental Design

This study assessed changes in hydraulic conductivity produced by air sparging in laboratory and field experiments. A variety of sediment samples with different grain size distributions were tested during laboratory experiments. A constant head permeameter, modified to facilitate air injection was used to determine the hydraulic conductivity of sediment samples during laboratory tests. A schematic diagram of the permeameter is shown in Figure 1 (Page 8). A permeable plate was clamped to the top of the permeameter. This held the sediment sample in place, while allowing both water and air to be discharged from the apparatus. Using Darcy's Law, the hydraulic conductivity of a sediment sample can be determined at any point in time by measuring: the drop in hydraulic head across the sediment column, the length of the sediment column, the cross sectional area perpendicular to the flow of water, and the discharge of water through the sediment sample.

Laboratory tests consisted of determining the hydraulic conductivity of sediment samples before air was injected, during air injection, and for a period following air injection. The hydraulic conductivity of each sediment sample was determined before air injection. Air was then injected into each sediment sample at the following rates: 0.05, 0.1, 0.15, 0.2, 0.25, 0.33, 0.5, 1, 1.5, 2 and 3 cubic feet per minute (CFM). Air was injected at each flow rate for a period of approximately 10 minutes. At the end of the 10 minute period hydraulic conductivity was measured, following this the air flow rate was increased. Following air injection at 3 CFM the air flow was discontinued and hydraulic conductivity was measured. Values of hydraulic conductivity obtained before air injection were compared with hydraulic conductivities measured during and after air injection to assess the influence of air sparging.

Nine sediment samples were tested in during laboratory experiments. Sediments used are commercially available sands and gravels. Grain size distribution curves of these sediments are presented in Figure 2 (page 8). Sediments used in tests 2 through 6 are poorly-graded sediments ranging from fine-grained sand used in test 1 to fine-grained gravel used in test 6. Sediments used in tests 7,8, and 9 are well-graded.

Meaningful results were not obtained from laboratory test 1, hence the data are not presented. A deficiency of the laboratory apparatus is that it is not able to test fine-grained sand and finer sediments. The resistance to air flow in fine-grained sediments was sufficient to induce injected air to flow downward through the water filled chamber at the bottom of the permeameter and out of the permeameter through the filled reservoir, rather than upward through the sediment sample. This short circuiting phenomenon prevents fine-grained sands and all finer sediments from being tested with this laboratory apparatus.

Laboratory Test Data

Data from selected laboratory tests are presented in Figure 3:

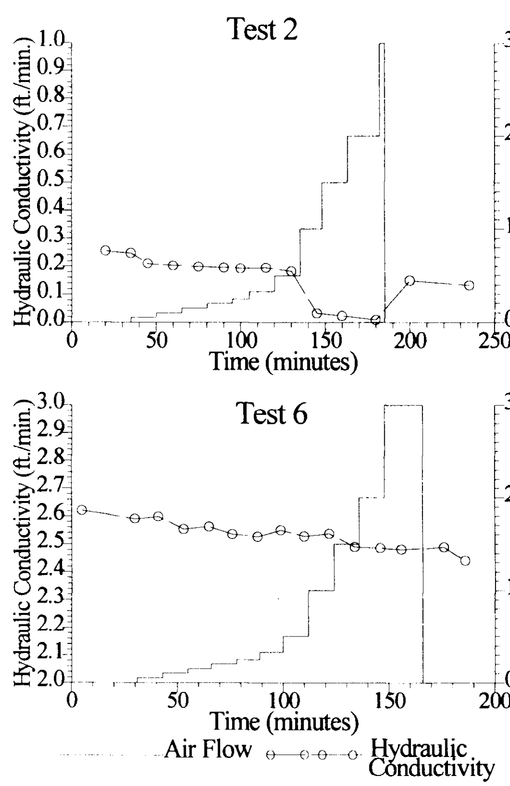

Figure 3. Data from laboratory tests 2 and 6.

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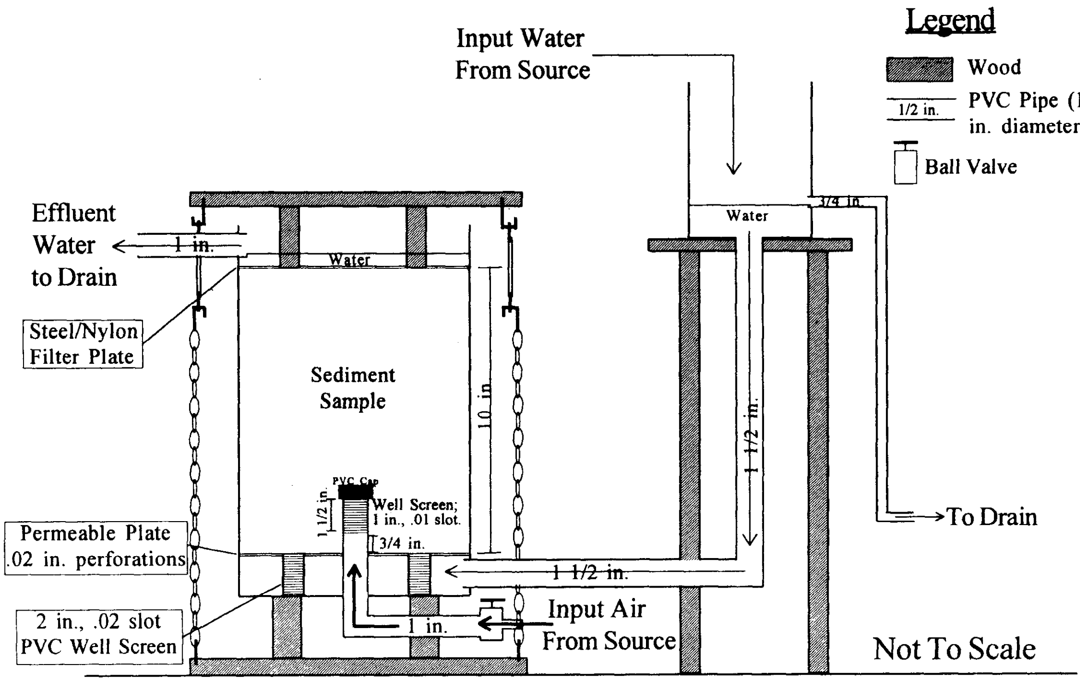

Figure 1. Modified constant head permeameter used in laboratory experiments.

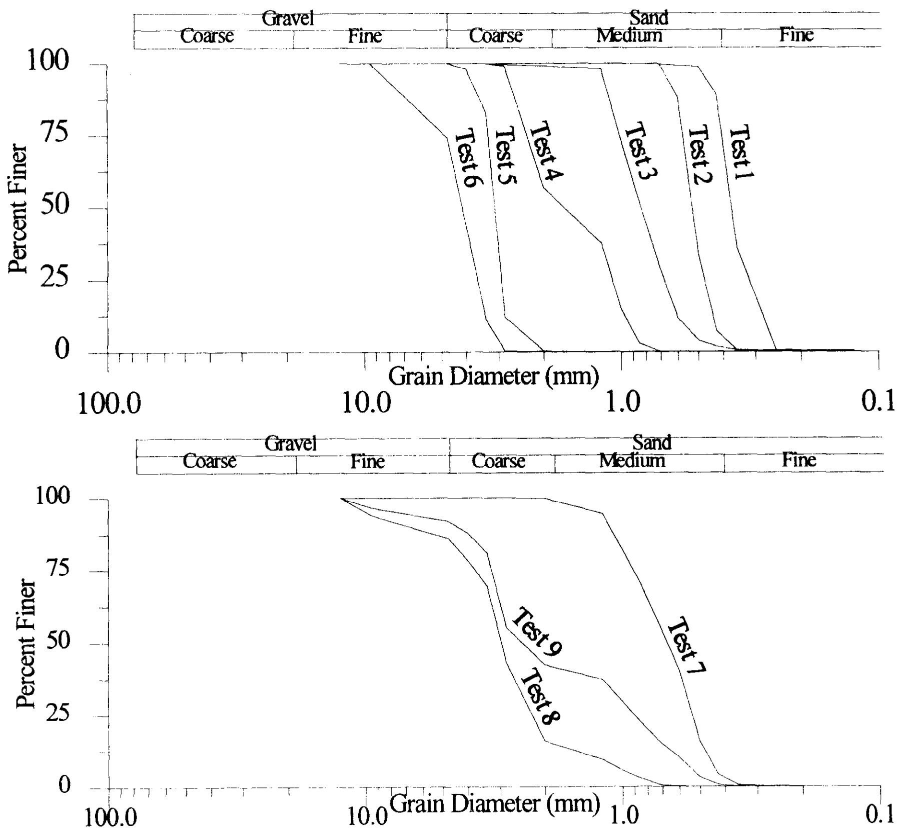

Figure 2. Grain size distribution of sediments used during laboratory tests.

Air Sparging and Hydraulic Conductivity, cont.

The sediments used in tests 2 and 6 are medium-grained sand and coarse-grained sand to fine grained gravel, respectively. During test 2 hydraulic conductivity was not affected at low air injection rates, while at high air injection rates (0.5 CFM and larger) it was reduced.

Data for all laboratory tests are summarized in table 1 (page 10). The maximum reduction in hydraulic conductivity is presented as a factor to which hydraulic conductivity was lowered during laboratory tests. This was calculated from the lowest measured hydraulic conductivity and a baseline hydraulic conductivity. The baseline hydraulic conductivity was calculated by averaging several data points before hydraulic conductivity was lowered at high air flow rates.

The largest reduction in hydraulic conductivity was measured during laboratory test 2 (medium grained sand). This was greater than an order of magnitude reduction, and was produced by injecting 2.5 CFM of air into the medium-grained sand tested. All other sediments tested showed a maximum reduction ranging from a factor of 4.4 to essentially no reduction for fine-grained gravel.

Laboratory Test Interpretations

The reduction in hydraulic conductivity is related to sediment grain size. Fine-grained sediments showed a larger maximum reduction in hydraulic conductivity than did coarse-grained sediments. This is likely the result of coarse-grained sediments having larger interconnected pore spaces. Hence a given amount of injected air will occupy a smaller portion of the total available interconnected pore space in coarse-grained sediments as compared to fine-grained sediments. This produces a smaller overall reduction in hydraulic conductivity for coarse-grained sediments.

The influence of heterogeneity was assessed during laboratory test 10. With the exception of this test, all sediment samples were relatively uniform. A non-uniform sediment was created by sieving sediment sample 4, separating grains greater than 2 mm in diameter and grains smaller than 1 mm in diameter from the rest of the sediment. This produced three sediments from the original sample. These subsamples were packed into the permeameter in randomly alternating thin layers. This produced a subtle layering which is believed by the author to more accurately represent the stratigraphy of most natural sediments.

Although tests 4 and 10 utilize the same sediment sample, the subtle layering present in test 10 more than doubled the reduction in hydraulic conductivity. This suggests that subtle lithologic variations may have a significant influence on the migration of injected air in aquifers. Both water and air preferentially flow through the largest available pores. When large amounts of air are present in a water saturated media, air will preferentially dewater and flow through larger pores forcing water to flow through smaller water filled pore spaces. When a limited numbers of large interconnected pores are available, as is the case for the stratified sediment in test 10, a larger reduction in hydraulic conductivity results.

Field Site Characteristics

The field site for this research is located within the Western Michigan University Asylum Lake Research Park, Kalamazoo, Michigan. The water table at the study site is approximately 17 feet below grade with ground-water flow toward the east, north-east. The vadose zone geology at the research site consists of clay to a depth of approximately 10 feet. Underlying the surface clay layer are glacial outwash deposits of sand and gravel. The unconfined aquifer consists of medium- to fine-grained sand.

The well field constructed for this research consists of ground-water monitoring wells and an air injection well (Figure 4). The air injection well (well 34) is constructed of an 1-inch diameter PVC screened from 28 to 33 feet below the water table. A network of monitoring wells was installed surrounding the air injection well. Monitoring wells are constructed of 2-inch inside diameter, flush threaded PVC with .01-inch slot screens of variable length. Artificial filter packs were not used in the construction of ground-water monitoring wells. Instead the aquifer material was allowed to collapse around the installed well screen. This may produce more representative values of hydraulic conductivity from slug tests, and minimize the creation of preferential air flow pathways adjacent to wells.

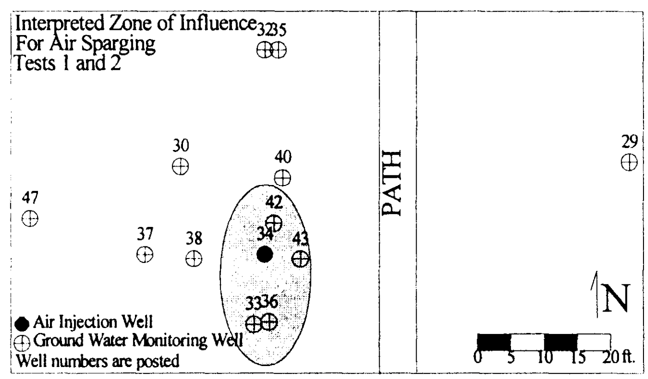

Figure 4. Zone of influence produced by air sparging.

Field Test Experimental Design

Field tests included several sets of slug tests and two air sparging tests. Aquifer hydraulic conductivity was determined using pneumatic slug test procedures. Slug tests were conducted before air sparging to determine a baseline aquifer hydraulic conductivity. The influence of air sparging was interpreted from comparing these initial values with slug test data obtained during and after air sparging tests. Time-displacement data from each slug test were recorded using a pressure transducer and data logger. The Bouwer and Rice method was used to analyze these data to obtain a value of hydraulic conductivity for each test.

For slug tests during and after air sparging, each well of interest was slug tested two or three times in sequence to

—continued on page 11

Table 1
Maximum Reduction in Hydraulic Conductivity
Determined From Laboratory Experiments

Test Number	D_{25} 75% Coarser (mm)	D_{50} Median Grain Size (mm)	Baseline Hydraulic Conductivity (ft./min.)	Lowest Measured Hydraulic Conductivity (ft./min.)	Factor of Hydraulic Conductivity Reduction
2	0.5	0.6	0.190	0.009	21
3	0.7	0.8	0.245	0.118	2
4	1	1.6	0.440	0.337	1.3
5	2.9	3.1	2.14	1.90	1.1
6	3.6	4.1	2.52	2.48	1.01
7	0.5	0.7	0.181	0.058	3.1
8	2.2	2.9	0.660	0.425	1.6
9	0.9	2.4	0.194	0.044	4.4
10	1	1.6	0.394	0.124	3.2

Table 2
Average Hydraulic Conductivities Determined From Slug Tests

Well No.	Pre- Air Sparging	Air Sparging Test 1	3 Hours After Air Sparging Test 1	1 Week After Air Sparging Test 1	Air Sparging Test 2 Step 3	Air Sparging Test 2 Step 5	17 Hours After Air Sparging Test 2	1 Week After Air Sparging Test 2
Wells Outside the Air Sparging Zone of Influence								
AL-30	.015		.018	.017				
AL-38	.010	.012	.013	.010				
Wells Within the Air Sparging Zone of Influence								
AL-33	.007	Turb*	.003	.015	Turb*	Turb*		
AL-42	.019	.005	.012	.021	.004	.007	.015	.023
AL-43	.014	.013	.011	.014	.013	.013	.015	.010

*Turb indicates slug tests were unable to be conducted due to excessive turbulence in the well.

Air Sparging and Hydraulic Conductivity, cont.

obtain an average hydraulic conductivity for each testing event. Five of the 12 wells in the well field were slug tested. Wells 30, 38, 33, 42, and 43 were slug tested. These wells were selected based on their proximity to the air injection well and well construction. The well construction of some wells does not allow effective slug tests to be conducted. Water table observation wells (wells 35, 36 and 37) have less than 1 foot of the five foot screened interval within the saturated zone and were therefore not tested. Water table observation wells were installed to measure the water table mound produced by air sparging and were not designed to facilitate slug tests. Wells 40, 29, 37 and, 32 were not within or adjacent to the air sparging zone of influence and were therefore not slug tested.

Prior to air sparging each well of interest was slug tested 10 times. This was done to determine: (1) the consistency and reproducibility of the slug test hydraulic conductivity data and (2) if the process of slug testing a well alters the value of hydraulic conductivity obtained from future slug tests. Slug testing could alter hydraulic conductivity if wells were initially inadequately developed allowing successive slug tests to further develop wells increasing the measured hydraulic conductivity. These pre-air sparging tests revealed that the measured hydraulic conductivity is relatively consistent between successive tests of the same well. No trend of increasing hydraulic conductivity is observed. This indicates that slug tests did not further develop the wells being tested, and that significant variations in hydraulic conductivity cannot be attributed to the variability of slug test measurements.

Two field air sparging tests were conducted. For each test air was injected using well 34. Air was initially injected at a low flow rate, 0.4 and 0.5 CFM for air sparging tests 1 and 2, respectively. Air flow rates were increased in steps, maximum air injection rates for air sparging tests 1 and 2 were 1.5 and 1 CFM, respectively.

Increases in well head space air pressures were used to interpret a zone of influence produced by air sparging. A large increase in head space air pressure results from air entering monitoring wells through the screen, bubbling through the water column, and accumulating in the head space. A significant increase in head space air pressure indicates that the well is screened within the zone of influence. During air sparging, test, wells were slug tested when the air sparging zone of influence was able to be identified and was stable. Slug tests were conducted at two intervals during air sparging test 2 and at a single interval during air sparging test 1.

Field Test Data and Interpretations

The interpreted zone of influence for field air sparging tests is shown in Figure 4, this zone of influence was interpreted for the time period during which slug tests were conducted. Four monitoring wells are within the zone of influence, wells 33, 36, 42, and 43. However, not all of these wells could be slug tested during air sparging tests. Well 36 is a water table observation well with a 6 inch water column, hence it could not be effectively slug tested. Well 33 was leaking a significant amount of air during both air sparging tests. This produced a crude air lift pump in the well which periodically raised the water level in the well 17 feet causing the well to be artesian. This prevented the well from being slug tested during air sparging , hence only hydraulic conductivity data before and after air sparging tests are available for well 33. During air sparging tests hydraulic conductivity data was only able to be obtained from wells 42 and 43.

Hydraulic conductivity data from field tests are summarized in table 2 (page 10). Each data point in table 2 is an average hydraulic conductivity from at least 3 slug tests of the same well for each time period. As would be expected, wells outside the air sparging zone of influence are not affected. Wells 33, 42 and 43 were within the zone of influence and were slug tested. Hydraulic conductivity data from well 43 are relatively consistent before, during and after air sparging. However, well 42 shows a factor of 3 to a factor of 5 reduction in hydraulic conductivity during air sparging. Although wells 42 and 43 are the same radial distance from the air injection well, the anisotropy of the aquifer favors air flow toward well 42, rather than well 43, hence well 43 is on the edge of the zone of influence, while well 42 is well within the zone of influence. Given their relative positions within the zone of influence, the density of air flow channels should be larger adjacent to well 42, relative to well 43. This larger density of air channels will consume a larger percentage of the available interconnected pore space, resulting in the observed reduction in hydraulic conductivity. Adjacent to well 43 the percentage of interconnected pore space consumed by injected air was much smaller and produced essentially no decrease in hydraulic conductivity.

Observations made using a down-hole video camera revealed that air entering monitoring wells produced turbulence in the water columns of wells screened within the air sparging zone of influence. This turbulence must be considered when interpreting slug test data. The effects of air sparging were interpreted by comparing slug test data obtained from static water columns (pre-air sparging slug tests) with slug test data from turbulent water columns (slug tests during air sparging). Wells 42 and 43 were leaking air to the surface during air sparging, hence both had turbulent water columns during air sparging. Before and after air sparging, water columns were static. Bouwer and Rice time-displacement plots reveal that for static and turbulent water columns there is a contrast in the sharpness of time-displacement data measured by transducers. Hence the quality of the straight line fit using the Bouwer and Rice method varies slightly. Water column turbulence has a small influence on the quality of transducer data. However, for both turbulent and static water columns, time-displacement data could be fit to a straight line. Water column turbulence does not have a significant effect on the calculated value of hydraulic conductivity. If water column turbulence were the cause of the observed reduction in hydraulic conductivity, the effect would have been observed in both of these wells. The reduction in hydraulic conductiv-

—continued on page 12

Air Sparging and Hydraulic Conductivity, cont.

ity observed during field tests cannot be attributed to water column turbulence.

Discussion and Conclusions

Both laboratory and field tests show that air sparging reduces aquifer hydraulic conductivity. Laboratory tests indicate that for a given air injection rate, the reduction in hydraulic conductivity is related to sediment grain size. Fine- to medium-grained sands showed a larger reduction in hydraulic conductivity relative to coarse-grained sediments. The reduction in hydraulic conductivity during laboratory experiments occurred only at relatively high air injection rates (1 CFM and greater). Injecting air at lower flow rates produced no observable effect. At the highest air injection rate (3 CFM) the hydraulic conductivity of the finest sediment tested (test 2) was reduced by a factor of 21. The hydraulic conductivity reduction of all other sediments tested during laboratory experiments ranged from no measurable reduction to a factor of 4 reduction, at the highest air flow rates (2.5 and 3 CFM).

Field hydraulic conductivity data also show a reduction in hydraulic conductivity related to air sparging. This effect appears to be limited to a small portion of the aquifer directly adjacent to the point of air injection. Portions of the aquifer outside this immediate zone of influence which were known to contain some injected air showed no significant reduction in hydraulic conductivity. In field tests, hydraulic conductivity was reduced by a factor of 3 to a factor of 5. Considering that values of hydraulic conductivity can span 12 orders of magnitude, data from field and laboratory tests suggest that air sparging in a relatively homogeneous media is unlikely to produce a widespread barrier to the flow of water in space or time.

The effectiveness of air sparging as a remediation technique is largely dictated by the density of air flow channels in an aquifer. The results of this study suggest that the density of air flow channels directly adjacent to an air injection well will likely be large. In other portions of the zone of influence air channel density will be lower. Hence the remediation rate may vary for different portions of the zone of influence.

Both laboratory sediment samples and the sandy aquifer tested in the field lacked large lithologic variations. The influence of air sparging on hydraulic conductivity may be somewhat different for extremely heterogeneous aquifers. The presence of heterogeneities may produce zones of lower hydraulic conductivity extending some distance from an air injection point.

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Reminder of 1996 newsletter editorial and publication submittal deadlines:

Volume 15, Number 2; June 1996
Submission of articles to the editor—5/10/96
Submission of copy to the publisher—5/17/96

Volume 15, Number 3; September 1996
Submission of articles to the editor—8/9/96
Submission of copy to the publisher—8/16/95

Volume 15, Number 4; December 1996
Submission of articles to the editor—11/8/96
Submission of copy to the publisher—11/15/95

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Thank you!

New Publications

New From the US Geological Survey:

USGS Water Resources Investigations Report 95-4151. *Presence, distribution, and potential sources of nitrate and selected pesticides in the surficial aquifer along the Straight River in north-central Minnesota, 1992-1993* by J.F. Ruhl.

USGS Water Resources Investigations Report 95-4105. *Effects of 1992 farming systems on ground-water quality at the Management Systems Evaluation Area near Princeton, Minnesota* by G.N. Delin, M.K. Landon, J.A. Lamb, and R.H. Dowdy.

USGS Water Resources Investigations Report 95-4216. *Water-quality assessment of part of the Upper Mississippi River Basin, Minnesota and Wisconsin — Volatile organic compounds in surface and ground water, 1978 -94* by W.J. Andrews, J.D. Fallon, and S.E. Kroening.

USGS Fact Sheet FS 192-95. *Withdrawal and delivery of water by municipal supplies in Minnesota, 1993* by L.C. Trotta.

New From the Minnesota Geological Survey:

Stearns County Geologic Atlas, 1995; County Atlas Series C-10, Part A.
Gary N. Meyer, Project Manager.

Plate 1, Database map
Plate 2, Bedrock geology
Plate 3, Surficial geology
Plate 4, Quaternary stratigraphy
Plate 5, Depth to bedrock and thickness of Cretaceous strata
Plate 6, Bedrock topography
Plate 7, Geologic resources

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Hydrogeology Summer Field Camp Taught

Field Hydrology (U of MN, Geo 5112), a new field camp offered through the Summer Session, was taught August 6 through 16, 1995. Its logistics base was at the University's Itasca Forestry and Biology Station, but much of the work was done at a new field site southeast of Akeley, MN, between Williams and Crystal Lakes. The Geology and Geophysics Department acquired a longterm lease to 20 acres of tax-forfeited land in Hubbard County, where an array of one pumping well and three monitoring wells were installed. At the Field Camp, faculty and students installed a fourth monitoring well as part of the curriculum.

The field site is within the study area of the long-term USGS Interdisciplinary Research Initiative (IRI) research project on lake-groundwater interactions at Williams and Shingobee Lakes. The field camp was fortunate in being able to make use of many of the USGS's facilities and personnel.

The camp was intense. The resident faculty, visiting faculty and graduate assistant typically worked 18-hour days. The students worked just as hard. Students were divided into teams for a series of modules covering subjects from surveying and geophysical techniques to aquifer tests and water sampling to collecting vadose zone, stream gage and weather data. The course also included a three-day pumping test that required around-the-clock monitoring by student-faculty teams.

The camp was taught by three resident faculty, Mark Person, Olaf Pfannkuch, and Calvin Alexander, plus a graduate student assistant, Steffan Fay, and about a dozen visiting faculty who came in to teach one- or two-day modules. This was the first time the faculty had taught such a field camp. According to Alexander, there were no disasters, only a few snafus, and many successes. In general, faculty and students were pleased with the camp. Student evaluations and faculty discussions resulted in many suggestions for next year aimed at improving a solid initial effort.

Twenty-one students completed the course. The students were a mix of advanced undergraduate and graduate students, adult special students, and included several UMD students and students from other universities. The adult special students included faculty from Bemidji State and Ashland, Wisconsin. The student from the most distant point was an undergraduate from the Univ. of Nevada. Next summer's field camp will be advertised more extensively to attract more students (24 is the optimum enrollment); but judging from the 1995 class, the advertising is reaching the intended audience. It is hoped that future student groups will be as diverse and dedicated as this first one was.

The camp will be taught this summer from August 1-22, 1996. Additional information may be obtained from Calvin Alexander at (612) 624-3517 or alexa001@maroon.tc.umn.edu.

From Minnegram, December 1995, a publication of the University of Minnesota Water Resources Research Center.

Support Your Association

Midwest Friends of the Pleistocene 43rd Annual Field Conference

May 31, June 1 and 2, 1996

The Midwest Friends of the Pleistocene will hold its annual field conference, FOP96, in northwestern Minnesota and eastern North Dakota the weekend of May 31-June 2, 1996. Registration and a social gathering will be held Friday afternoon and evening. We will conduct a field trip all day Saturday, and convene the annual banquet and business meeting Saturday evening. Fred Schneider will present a talk on the archaeological implications within the Lake Agassiz plain at the banquet. There will be a field trip Sunday morning.

The Saturday field trip, in northeastern ND, will consist of a wide variety of stops including a site of saline groundwater discharge from truncated Cretaceous subcrops, a large spring pit, exposures of tills, the Edinburg moraine, the Soo and Lankin moraines, the Dahlen esker, the Elk Valley delta, and shoreline features of Lake Agassiz. The Sunday trip, in northwestern MN, will focus on till stratigraphy. Cutbanks along the Red Lake River expose six tills and lake sediment. The lithology and texture of these tills reflect distinct source areas. Of particular interest are the thin tills, abundant fossil wood, and a variety of insect remains.

The post-FOP96 field trip is planned for Sunday afternoon through Monday. We will travel in vans from Grand Forks, ND to the southern outlet of Lake Agassiz. This field trip will examine sites associated with the southern Lake Agassiz basin, including compaction ridges, a buried tunnel valley, an example of engineering problems in the valley, the Sheyenne delta, a paleo-Indian site, Holocene sand dunes, an exposure along the Sheyenne River valley, and the southern outlet of Glacial Lake Agassiz.

For more information contact Ken Harris (612)627-4809, e-mail harri015@maroon.tc.umn.edu

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