Illinois Groundwater Association

2002 Fall Meeting

Program with Abstracts

Holiday Inn

1001 Killarney Rd, Urbana, IL

Wednesday, November 13, 2002

AGENDA
Illinois Groundwater Association 2002 Fall Meeting
Holiday Inn, Urbana, IL
Wednesday, November 13, 2002

8:15 - 9:20 Registration - Coffee, Doughnuts, Muffins, and Bagels

9:20 - 9:30 Opening Remarks: Colin Booth, IGA Chair

Session 1

9:30 - 10:00 Dr. Henk Haitjema, Indiana University
Analytical Element Modeling of Groundwater Flow

10:00 - 10:20 George Roadcap, Illinois State Water Survey
Groundwater Modeling of the Mahomet Aquifer: From Conceptual Models to Post-Audits

10:20 - 10:40 Andre Pugin and Tim Larson, Illinois State Geological Survey
High-Resolution Geophysical Investigation of the Buried Mahomet Valley West of Monticello, Illinois

10:40 - 11:00 ***Break/ Vote for Officers***

Session 2

11:00 - 11:20 Tom Holm and Steve Wilson, Illinois State Water Survey
Arsenic Geochemistry and Distribution in the Mahomet Aquifer

11:20 - 11:40 (cancelled) Sean Hoffman, Micropack, Inc.
Siting & Development of a Bottled Water Plant and Micropack's Water Processing

11:40 - 12:00 Dr. Tom Johnson, University of Illinois, Department of Geology
Stable Isotopes in Groundwater: Not Just for Academics Anymore

12:00 - 1:15 ***Lunch***

Session 3

1:15 - 1:35 Dr. Steve Van der Hoven, Illinois State University
Dissolved Helium as a Tracer for Flow in the Mahomet Aquifer

1:35 - 1:55 Dick Berg, Illinois State Geological Survey
New Aquifer Sensitivity Classification for Illinois

1:55 - 2:10 ***Break***/ Count Votes

2:10 - 2:30 Derek Winstanley, Illinois State Water Survey
Water Supply Planning and Management in Illinois: An Update

2:30 - 2:50 Illinois Groundwater Association, Business Meeting (release election results)

Analytic Element Modeling of Groundwater Flow

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Computer modeling of groundwater flow is usually based on the Finite Difference Method or the Finite Element Method. In the early 1980's the "Analytic Element Method" (AEM) was introduced, which employs superposition of many (hundreds) of analytic functions to define solutions to mostly regional groundwater flow. A "discharge potential" function is used to solve flow in realistic heterogeneous aquifer settings under both confined and unconfined flow conditions. Three-dimensional solutions are developed to include local 3-D effects in regional models. The AEM appears particularly suitable for quick model deployment under conditions of scarce field data. In addition, due to the absence of a spatial grid or element network, the AEM can handle large model domains without loss of resolution in areas of interest.

The analytic element model GFLOW 2000 is a Windows based computer program for modeling steady state flow in shallow aquifers. Its capability to solve groundwater flow and surface water flow in stream networks conjunctively greatly enhances the realism in the way hydrologic boundaries are represented. This feature also offers additional (baseflow) calibration targets, which helps in determining both the regional recharge rate due to precipitation and the regional hydraulic conductivity. The fact that analytic elements directly represent hydrologic and geologic features makes model development intuitive and efficient. The analytic element method is also uniquely suitable for a stepwise modeling approach, starting with a very simple model and increasing its complexity as the groundwater flow system is better understood. Stepwise modeling is also cost efficient in terms of field data requirements, avoiding redundant or irrelevant field data collection.

An education version of GFLOW 2000 and documentation may be downloaded for free from www.haitjema.com A comprehensive discussion on AEM modeling is found in "Analytic Element Modeling of Groundwater Flow" Henk Haitjema, Academic Press, 1995.

Groundwater Modeling of the Mahomet Aquifer: From Conceptual Models to Post-Audits

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Modeling flow in a complex glacial sand such as the Mahomet Aquifer in central Illinois is extremely challenging because the flow system is fairly large (150 miles long and 10 to 30 miles wide) while the controlling hydrogeologic features are often relatively small (< 1/4 mile in size). Portions of this glacial system have been studied with 2-D and 3-D sub-regional models with some success while attempts to model the entire aquifer with 2-D models have had less success. Successful calibration of the models is most dependent on developing a proper conceptual model of how recharge enters the aquifer from scattered interconnections with overlying sand layers and streams. Many iterations of the aquifer geometry and stream connections in localized areas are often necessary to reproduce hydraulic head distributions with a model as well as explain observed geochemical and isotopic distributions. In the west-central portion of the valley where the geology has been studied extensively, a 7-layer model with two overlying sand aquifers and a 1/4-mile grid spacing was necessary to model flow in the Mahomet Aquifer. Without this level of detail, accurately modeling the entire aquifer has not been practical.

Groundwater flow models are often used to predict the impacts of large water withdrawals on unstressed aquifers. Without the appropriate field data collected during the stressed condition, the accuracy of the calibrated model parameters may be limited. A reexamination, or post audit, of a model after a new wellfield stress has been developed can provide critical information to improve the calibration of the model and to better characterize the geology, hydrology, and chemistry of an aquifer. A sub-regional model of the central portion of the Mahomet Aquifer was created by a consultant to predict the impacts of ten emergency water supply wells operated by the City of Decatur. After the model was completed, a drought occurred in 1999 which forced Decatur to pump their wells for 84 days at daily rates from 3 to 16 million gallons a day (mgd). A post audit of the model revealed that the model-calculated water levels were a poor match to the measured water levels under stressed conditions. The largest error occurred along the Sangamon River in Piatt County where the model significantly over-predicted the drawdown. From a review of test boring logs, groundwater levels and river stages, geochemical analyses, it was hypothesized that there is a connection between the river and the aquifer. By adding river cells to the model to simulated this hypothesized connection, the calibration was greatly improved.

High-Resolution Geophysical Investigation of the Buried Mahomet Valley West of Monticello, Illinois

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Within the buried Mahomet Valley in central Illinois, the glacial sediments are characterized as multiple aquifers and aquitards. The valley fill of the buried fluvial valley (Mahomet sands) is the most important aquifer in central Illinois. Subsequent glacial events have deposited two major groups of till units, the Glasford Formation (Illinois Episode) and the Wedron Group (Wisconsin Episode). Hydro-chemical studies suggest that the unusually young water in the Mahomet sand aquifer may be connected to overlying aquifers. In collaboration with Illinois State University students, Bloomington, IL, we have applied geophysical techniques to improve the understanding of the 3-D sedimentary architecture for a mapping project. Our high-resolution geophysical imaging included 20 km of P-Wave (compression), 7 km of SH-Wave (horizontal shear) seismic reflection, and 1.7 km of resistivity profiles. VSP (Vertical Seismic Profiles) and gamma logs conducted in 6 boreholes provided calibration. The most surprising results were not associated with the Mahomet sands, but with the overlying sediments. A 1 km wide and 50 m thick Illinois Episode subglacial tunnel-valley eroded through the Glasford till then was filled with sand. Similar features, called Ridge-drifts, can be observed at the surface on the Illinoian till plain, 40 km further south. Another important result obtained with the geophysics and confirmed by borehole data is that the modern Sangamon River flows in a 30 m thick coarse-sediment channel that cuts through the Wedron tills. We suggest that where these two channel features cross, a hydraulic window connects shallow aquifers, and possibly the surface river water, with the lowermost aquifer.

Arsenic Geochemistry and Distribution in the Mahomet Aquifer

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The Mahomet Aquifer in central Illinois is the source of drinking water for many communities and thousands of private homes. Arsenic (As), a suspected carcinogen, has been found in some areas of the aquifer at concentrations that exceed the former maximum contaminant level (MCL) of 50 micrograms per liter (ppb). Because the MCL was recently lowered to 10 ppb, many more areas of the aquifer now exceed the MCL. The aquifer is confined for most of its area and the available data suggest that the highest As concentrations may be found near the upper confining layer. One of the objectives of this proposed research is to characterize the depth distribution of As in the aquifer. A second objective is to determine As speciation in the aquifer system. Arsenic in ground water occurs in two chemical forms or species, As(III) and As(V). The chemical and toxicological properties of the two species are quite different. Thermodynamic calculations indicate that As(III) should be the predominant form in the aquifer system, but there have been few measurements of As speciation in the system. We selected approximately 50 private wells each in Tazewell and Champaign Counties on the basis of location and depth. We collected groundwater samples from these wells and analyzed them for total As, As speciation, and supporting chemical measurements.

Siting & Development of a Bottled Water Plant and Micropack's Water Processing

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Cancelled.

Stable Isotopes in Groundwater: Not just for academics anymore

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The academic community applies stable isotopes as tracers of water and solute transport, and as indicators of chemical reactions, in groundwater systems. Increasingly, stable isotope approaches are becoming practical and affordable tools for water supply and contaminant migration projects outside academia. There are several isotopic tools that should be in every hydrologist's toolbox, and many others that can be brought in for special situations.

In stable isotope analysis, we exploit the fact that light and heavy isotopes of a given element are slightly different chemically. For example, when water evaporates from a lake, there is a slight preference for the lighter O and H isotopes to evaporate, relative to the heavier isotopes. We measure the heavier isotope: lighter isotope ratio as a way of quantifying these effects. The variations are very small (usually <1%), so specialized mass spectrometers are needed and analysis costs tend to be greater than other chemical measurements. However, costs have decreased for some stable isotope analyses and practical use is increasing rapidly. The Illinois State Geological Survey has long been at the forefront of work in this area, performing basic research to develop the tools and routine analyses for important projects. Examples of several types of isotope studies will be presented in this talk.

O and H isotopes in precipitation vary seasonally, or even from storm to storm, providing the possibility of tracing recharge and groundwater transport in small catchments. Also, water that has been subjected to moderate to intense evaporation has a distinctive "signature". River water or drinking water may have H and O isotope ratios that are distinct from local recharge. Carbon and chlorine isotopes are being developed as indicators of the sources and degradation rates of organic contaminants and chlorinated solvents. Similarly, sulfur, nitrogen, iron, chromium, and selenium isotope ratios can indicate sources of and chemical reactions involving these elements. Each of these potential applications will be briefly described.

Helium as a Tracer for Flow in the Mahomet Aquifer

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Groundwater acquires dissolved helium from two main sources: the dissolution of helium in the atmosphere and subsurface production by the uranium/thorium radioactive decay series. The atmospheric contribution to dissolved helium is fixed at the time of recharge, while the "radiogenic" component increases with time along a groundwater flow path. In a groundwater sample, contributions from each component is calculated based on characteristic $^{3}He/^{4}He$ ratios. If the rate of accumulation of radiogenic helium is known, apparent groundwater ages can be calculated. Recent evidence indicates that helium has potential as a dating techniques for groundwater in the age range of 100's to 1000's of years in recently eroded glacial sediments. Helium also has also been used as a conservative tracer in a transport models of large basins in other parts of the world.

Helium samples were recently collected from wells screened in glacial sediments in Ford, Champaign, Iroquois, and Vermillion counties. As initially hypothesized, helium concentrations increase with depth in these wells. Spatial variability in the depth relationship corresponds well with previous interpretations of groundwater flow in the glacial sediments based on hydraulic head and major ion chemistry. Radiogenic helium concentrations divided by ^{14}C ages available for some wells provide a first estimate of accumulation rates.

These first results show promise, but further work is needed to establish the value of helium as a tracer in this setting. Future work includes 1) current experiments under way to measure the release rate of helium from sediments, 2) measuring the helium concentration in the bedrock underlying the glacial sediments, particularly in areas where major ion chemistry indicates and advective flux from the bedrock, 3) collection of additional data to better define the spatial patterns of helium concentrations within the glacial sediments. Ultimately, helium by itself or in combination with another conservative tracer (Cl^- or perhaps SO_4^{-2}), can be used in transport models to provide additional constraints on the groundwater flux in the Mahomet aquifer system.

New Aquifer Sensitivity Classification for Illinois

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A new scheme for classifying geologic successions according to the sensitivity of their aquifers to contamination from surface sources was developed and published by the Illinois State Geological Survey (ISGS) in 2001. Although the classification scheme focuses on the presence of sand and gravel or high-permeability bedrock aquifer materials lying within 100 feet of land surface, it can accommodate aquifer materials at any depth. Based on various aquifer sensitivity rating schemes used in numerous published ISGS maps and reports, this new scheme provides a single uniform classification that mappers can employ when developing aquifer sensitivity maps for anywhere in Illinois, and at any scale. It is NOT intended that this classification system be used as a regulatory tool.

Currently, geologic mapping is the largest single program within the ISGS, and we expect that aquifer sensitivity maps will continue to be important derivative products of the program. If new technologies and methods for determining the in-place hydrologic properties of geologic materials become available, then innovative ways to more accurately assess and map the sensitivity of aquifers to surface contamination will almost certainly be developed. However, until such technologies become viable, we chose to develop a classification scheme based on parameters that can be easily determined while compiling a three-dimensional geologic map from land surface to the bedrock surface. In this scheme, the thickness of the first layer of aquifer materials, its depth below the land surface, and the relative thicknesses of aquifer (coarse-grained or fractured, relatively permeable) and non-aquifer (fine-grained, relatively impermeable) materials in the succession are considered the most important parameters.

The following generalizations and assumptions are included in the new classification and mapping scheme:

- Aquifers are defined according to state statute - sand and gravel and high-permeability bedrock of a specified thickness.
- Sensitivity classes are based on depth to the shallowest aquifer layer.
- No distinction is made between sand and gravel and bedrock aquifers, except that cemented sandstone is considered a low-yielding aquifer.
- Aquifer thickness categories are <20', 20-50', and >50'.
- Mappable aquifers have an areal extent >40 acres.
- Aquifers at land surface are divided into 2 categories - within 5' of surface or at 5-20'.
- Categories may be added to accommodate discontinuous aquifers or other uncertainty about the extent or thickness of aquifer layers.
- Sandy diamictons (>40% sand), which are probably too permeable to be considered aquitards, are shown by an overprint pattern.
- An overprint pattern can be used to show the presence of sand and gravel aquifers buried at

>100' or below shallower aquifer layers.

- An overprint pattern is used to show carbonate bedrock in karst terrains.
- Disturbed land and water are shown by gray and blue patterns, respectively.

Primary map units (A to F) to be shown on aquifer sensitivity maps are listed in order of decreasing aquifer sensitivity and 24 individual rating classes are defined. Red, orange, and yellow shades on a map (A, B, and C classes) indicate high to moderate sensitivity, while green and blue shades (D, E, and F classes) designate moderately low to low sensitivity. Sand and gravel or high-permeability bedrock layers >50' thick within 5' of the land surface are the most sensitive setting in the state (even more sensitive if the bedrock is in a karst region), while <20' of fine-grained unlithified material overlying unfractured shale or carbonate bedrock is the least sensitive.

Water Supply Planning and Management in Illinois: An Update

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For 70 years Illinois has challenged itself to undertake comprehensive assessments of water quantity statewide, including the production of an Action Plan in 1967. The challenge is still alive and well. This presentation summarizes recent events and reports related to water-quantity assessments and calls for improved planning and management of groundwater and surface water. In June 2000, Governor Ryan established by Executive Order a Water Resources Advisory Committee, with focus on peaker power plants. This was followed in April 2002 by an Executive Order requiring the Interagency Coordinating Committee on Groundwater to report each January on water quantity assessments and a water-quantity planning procedure. In October 2001, the Illinois State Water Survey and Illinois State Geological Survey produced reports identifying scientific studies that need to be undertaken to improve the scientific basis for water-quality assessments. Proposals for new water-quantity protection legislation also have been put forward. Progress is being made, but fulfilling the 70-year challenge will require additional resources for science and research, and continued consensus building, and political leadership.