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2007 Fall Meeting

Northern Illinois University-Naperville, Naperville, IL

October 4, 2007

Program with Abstracts

AGENDA

Illinois Groundwater Association
Fall 2007 Meeting
October 4, 2007

Northern Illinois University-Naperville
Naperville, Illinois

8:30–9:00	Registration
9:00–9:10	**Don Keefer, IGA Chair,** *Illinois State Geological Survey,* Opening Remarks
Morning Session	
9:10–9:40	**Doug Cherkauer**, *University of Wisconsin-Milwaukee,* Ground Water Supply Issues in SE Wisconsin: Assessing Problems and Possible Solutions
9:40–10:10	**Rick Cobb,** *Illinois Environmental Protection Agency,* Demonstration of Illinois EPA Source Water Assessment Program On-Line Interactive Database
10:10 - 10:25	**Break**
10:25–10:55	**Lisa Rauh,** *Northern Illinois University,* A Hydrogeologic Site Investigation of the Former Monarch Foundry, Plano, Illinois
10:55 – 11:25	**Tim Grundl,** *University of Wisconsin-Milwaukee,* Water Quality in the C-O Sandstone Aquifer with Emphasis on Radioactivity and Salinity
11:30 – 12:15	**LUNCH (provided)**
12:15 – 1:00	Open Discussion
Afternoon Session	
1:00 – 1:30	**Ed Mehnert,** *Illinois State Geological Survey,* Analytical Element Modeling of Blackberry Creek, Kane County, Illinois
1:30 – 2:00	**Ken Bradbury,** *Wisconsin Geological & Natural History Survey,* Finite-Difference Modeling of Regional Aquifer System Below Southeastern Wisconsin
2:00 – 2:30	**Brandon Curry,** *Illinois State Geological Survey,* Origin and Evolution of Illinois' Longest Caves: An Integrated Approach to Interpreting the Geologic and Paleoclimatic Records
2:30 – 3:00	**Break**
3:00 – 3:30	**Randy Locke**, *Illinois State Water Survey,* Geochemical Responses at Lake in the Hills Fen Nature Preserve to Aggregate Mine Reclamation
3:30 – 4:00	IGA Announcements, Agency/Survey Reports, Open Microphone
4:00 – 4:15	**Don Keefer,** Closing Remarks
4:15	**Adjourn**
4:15 – 5:00	IGA Executive Committee

ABSTRACTS

Ground Water Supply Issues in Southeastern Wisconsin: Assessing Problems and Possible Solutions

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In the Midwest, the historic response to increased demand for ground water has been to increase extraction rates. New wells have been sited and designed with an emphasis on quantifying drawdowns and potential interferences and minimizing costs. Rarely have we determined the ultimate source of the extracted water, whether the system can sustain the supply, or whether the impacts (on environmental systems and other ground-water users) are acceptable.

Recent legislation in Wisconsin designed to protect ground-water quantity perpetuates this one-dimensional approach. It identifies Ground Water Management Areas (GMAs) as those in which drawdown exceeds 150 feet. Such areas are then ordered to develop a water management plan to mitigate the situation. Southeastern Wisconsin has been identified as one of two GMAs in the state, and the Southeast Wisconsin Regional Planning Commission (SEWRPC) is in the process of developing a management plan for 2035.

It is considering a variety of possible alternative management options which include: expanded extraction of ground water, shifting that extraction from a heavily-impacted confined aquifer to an unconfined system, augmenting recharge to the unconfined aquifer and switching ground-water users to Lake Michigan, where it is legal. Their objective is to find a combination of alternatives that is cost-effective, minimizes impacts to surface water baseflows and also reduces drawdowns.

In order to compare the viability of different options, quantitative measures of impacts and sustainability, in addition to drawdown, are needed. Three indices which compare ground-water budget components will be presented:

1. The ratio of demand to natural supply provides a measure of sustainability,
2. A ratio which shows the relative impact of human activity on the ground water budget,
3. A measure of the reduction of ground water discharge to surface water bodies.

The first two are modifications of ratios developed by Weiskel, et al (WRR, 43(4)).

These indices are defined and their historical distribution in southeast Wisconsin is presented and interpreted. In the region's confined aquifer the first two produce very similar results to drawdown. However, all three of these measures fail miserably to assess the effects of pumping in unconfined aquifers. Here surface water bodies are the ultimate source of most of the water extracted from wells. When, as in Wisconsin, the bulk of that water is disposed of in select rivers, the baseflow of all other surface waters drops significantly.

The planning process has not progressed far enough to allow presentation of ground water budget impacts under future development options. However, results from one test case will be presented.

Source Water Assessment and Protection (SWAP) Internet Geographic Information System (GIS)

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The Illinois Environmental Protection Agency (Illinois EPA) worked with the United States Geological Survey to develop the SWAP Internet GIS with the cooperation of the Illinois State Geologic Survey and Illinois State Water Survey. One of the intents of the design of the SWAP Internet GIS was to provide assessment data to stakeholders in order assist with implementing protection programs. The utility of the application, while somewhat limited by 911, has expanded too many other areas primarily because of the new right-to-know law and accompanying regulations. Furthermore, Illinois EPA project managers and field staff are routinely using this application for hydrologic evaluation of sites. The application is a valuable screening tool for consultants and others conducting environmental work.

A Hydrogeologic Site Investigation of the Former Monarch Foundry, Plano, Illinois

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The former Monarch Foundry is an abandoned manufacturing facility in Plano, Illinois. The building's use has varied throughout time, including the production of cast-iron gears and chrome-plated faucets. Heavy-metal byproducts and other industrial wastes were discarded onsite and remain to this day. The location of the site is directly adjacent to the Big Rock Creek and is about 800 feet away from the city's three municipal-supply wells. The goal of this research is to perform a hydrogeologic site investigation at the former Monarch Foundry and nearby city wells. The objectives of this research are (1) to determine aquifer parameters and characterize flow, (2) to examine water chemistry, and (3) to model the groundwater flow. The data collected will be placed into a Geographic Information System to aid in the understanding of the field site. Research completed thus far mainly deals with the first objective. Pneumatic slug tests were performed on all monitoring wells at the site, and results were analyzed with two different software packages. Continued research will lead to the prediction of the extent of contamination and eventual re-design of a five-year recharge area.

Water Quality in the Cambro-Ordovician Aquifer with emphasis on Radium and Salinity

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The Cambro-Ordovician aquifer in eastern Wisconsin is confined by the Maquoketa Shale near the Lake Michigan coast and is unconfined to the west. The primary recharge area is near the transition point from unconfined to confined conditions. The transition from unconfined to confined conditions causes a large change in both flow pattern and aquifer geochemistry. Data will be presented to show that increases in salinity and radium activity, changes in the major ion character of the groundwater and mineral saturation indices are all linked to this transition.

Speciation modelling (PHREEQC 2.7) combined with a detailed understanding of the regional flow system provided by recent flow modelling efforts is used to show that control of radium activity is dominated by co-precipitation into two sulfate minerals, barite and celestite. In the actively flushed, unconfined portion of the aquifer the only sulfate mineral at saturation is the very insoluble barite. Barite co-precipitation holds radium activities to below the federally mandated level of 5 pCi/L total radium. In the poorly flushed, confined portion, celestite is found at saturation and co-precipitation control shifts to this mineral. Calculations based on published distribution coefficients and the observed Ra:Ba and Ra:Sr atomic ratios indicate that the concentration of radium in these two minerals is between 12 and 21 μg/kg.

^{14}C ages of ground-water samples indicate the presence of water as old as 28kyr BP. Noble gas data in conjunction with stable isotopes indicate a cooling of about 6.5 to 7° C during the last glacial period compared with the modern temperatures. Stable isotopes indicate that none of the waters contain any significant portions of glacial meltwater, therefore samples with ^{14}C ages between 12 and 26 kyr BP, which is the time when the area was ice covered, most likely infiltrated from the surface and do not represent direct subglacial recharge. This large, one-time influx of fresh Pleistocene water has implications for water supply planning decisions.

Analytical Element Modeling of Blackberry Creek, Kane County, Illinois

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An analytical element (AE) model was developed to analyze steady-state, shallow groundwater flow and streamflow for the Blackberry Creek watershed. The AE model was developed using GFLOW software (www.haitjema.com) and requires limited input data. Input data include hydraulic conductivity, aquifer thickness, recharge and heads within and around the watershed. As described by Haitjema (1995) and Hunt (2006), AE models can be developed in a sequential or stepwise fashion, where the models increase in complexity when justified by the observations. Increasing complexity might be needed to show where a deep aquifer and shallow aquifer connect or where an aquifer discharges to a stream. In addition, unique estimates of recharge and hydraulic conductivity (r/K) are possible if surface water flow data are available (Sanford, 2002).

The purpose of this project is twofold: to develop a model of shallow groundwater and surface water flow for the Blackberry Creek watershed with special interest in estimating groundwater recharge in the watershed; and to demonstrate the utility of AE modeling to improve geologic mapping/modeling.

The Blackberry Creek watershed covers more than 70 square miles in southern Kane County and northern Kendall County and has more than 400 feet of elevation change. It was selected for study because of its location in Kane County, stream order (low order preferred), availability of streamflow data (USGS stream gages at Montgomery and Yorkville), and interest by local groups such as the Fox River Study Group.

An increasingly complex model was developed to explain the available data. First, a nonunique solution was developed to fit streamflow at Yorkville and surrogate groundwater levels. Numerous solutions were possible by varying the recharge rate and discharge from a shallow aquifer. Detailed streamflow data, collected at 10 stations in June 2007, allowed a unique solution to be developed. This unique solution includes three special areas— three areas of deep groundwater discharge to shallow groundwater and an area of reduced recharge. AE flow modeling allows one to test conceptual models of groundwater flow identified and interpreted from geologic mapping. Additional streamflow data may be needed to refine the watershed-based flow model.

Regional Hydrogeology and Groundwater Flow Modeling in Southeastern Wisconsin

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Recently completed hydrogeologic studies in southeastern Wisconsin provide an improved understanding of the groundwater system and new tools for water-supply planning and decision making. A groundwater flow model created for the seven counties that make up the Southeastern Wisconsin Regional Planning Commission (SEWRPC) region is being used to quantify the effects of long-term pumping on the natural circulation and replenishment of that area's groundwater. The model simulates groundwater movement through the entire geologic section extending from glacial and dolomite units near the land surface to sandstone units at depths of more than 2,000 feet. The model includes surface-water features such as Lake Michigan, major rivers, lakes, and wetlands, and computes a groundwater component of the water budget for these features. By incorporating all known municipal and industrial wells operating now and in the past into transient runs, the model illustrates the evolution of groundwater levels and flows between 1864 and 2000 and allows predictions of future conditions.

Model results show how intensive groundwater use has influenced the groundwater flow system throughout the SEWRPC area and beyond. Groundwater withdrawals have created a regional cone of depression. Water levels in the deep aquifer have dropped about 500 ft since the early 1900s and continue to decline at about 6 ft/yr. Historically, groundwater in the region discharged into Lake Michigan along the shoreline and through slow upward seepage through the lake bed. In some areas pumping has reversed these natural flow directions, but the total induced seepage out of the lake remains very small relative to the total lake water budget. Pumping has also reduced groundwater discharge to springs, other lakes, and wetlands, has shifted groundwater divides, has increased flow from the shallow to the deep parts of the aquifer system, and has altered groundwater flow directions. Predicted future groundwater usage will likely accelerate these changes.

The US Geological Survey has developed a web page describing the model, with emphasis on groundwater interactions with the Great Lakes: http://wi.water.usgs.gov/glpf/index.html

Origin and Evolution of Illinois' Longest Caves: An Integrated Approach to Interpreting the Geologic and Paleoclimatic Records

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We are currently taking a holistic approach to investigate the origin and evolution of long, branchwork-type caves and their deposits in southwestern Illinois. Fogelpole Cave and Illinois Caverns are Illinois' longest caves, 24 and 10 km, respectively. Both caves have active streams flowing through them. They also contain abundant fluvial sediment, slackwater lacustrine deposits, bedrock-defended terraces, flowstone, stalagmites, stalactites, and breakdown. Collectively, these features show evidence of past climate change, large floods and major earthquakes. By systematically mapping and dating these deposits and landforms, we are beginning to see correlations among groups of deposits and relationships to specific historic and prehistoric climatic and seismic events. From these results, we are developing a conceptual model of the timing and mode of cave initiation, development and deposition of sediment and speleothems within the caves and their relationship to paleoclimatic conditions.

To date, the results we have obtained suggest that the formation of large caves in southwestern Illinois was initiated at 140,000 and 170,000 years BP during the Illinois Glacial Episode. Subsurface karst processes were enhanced by glacial meltwater that flowed down vertical fractures and thence along bedding planes of the calcite-rich St. Louis Limestone. A subterranean dendritic drainage pattern was established with the main trunk cave stream discharging at springs and streams that eventually reach the Kaskaskia River. The continuous flow of water through these developing crevices and conduits resulted in additional dissolution of rock and down-cutting of the caves that continues today (overall incision rates appear to have ranged from 0.032 to 0.048 cm/yr). Remnants of flowstone and cemented alluvial gravels near the cave ceilings and stalagmites on subterranean bedrock-defended terraces provide evidence of former stream levels. One deposit of cemented gravel, located about 1 m below the cave ceiling, was deposited about 114,000 years ago. During the last glaciation (Wisconsin Episode), side passages were filled with silty sediment in subterranean slackwater lakes that formed due to blocked drainage. Clay mineralogy reveals the lake sediment is composed of glacial sediment that was redeposited in the caves possibly during a period of landscape instability probably caused by rigorous continental conditions (i.e., high climatic variability). U-series ages of calcite bounding thin layers of silt in two well-dated stalagmites point to a particularly large flood at about 50,000 years ago.

In some areas, cave decorations or sediment have overgrowths of small, white stalagmites. U-series ages and travertine layer counting reveal that they began forming either ≈90 or 190 years ago. These ages correlate with two major earthquakes in the region, one that occurred in 1917 and another in 1811-12, the latter being generated by the New Madrid seismic zone. These results indicate that caves contain a wealth of paleoclimatic and possibly seismic information which we are only beginning to uncover.

Geochemical Responses at Lake in the Hills Fen Nature Preserve to Aggregate Mine Reclamation

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Lake in the Hills (LITH) Fen Nature Preserve is a 207 acre site in southeastern McHenry County, Illinois and was dedicated to the Illinois Nature Preserve System in 1990. The Illinois State Water Survey (ISWS) and Illinois State Geological Survey (ISGS) have collected detailed geologic, hydrologic, and geochemical information from the preserve since 1998 to address concerns of the Illinois Nature Preserves Commission (INPC) related to groundwater effects on the preserve from adjacent aggregate mining.

Between May 1999 and April 2002, 232 groundwater samples were collected during 24 sampling events from 17 wells. Between May 1999 and December 2006, selected parameters were monitored in situ using water-quality data loggers in 4 wells. Data loggers were effectively used to document short- and long-term groundwater trends in low-maintenance parameters (e.g., specific conductivity, temperature, and water level), but were marginally effective to ineffective for higher maintenance parameters (e.g., pH, oxidation reduction potential, and chloride).

A small test pit less than one acre adjacent to the preserve was partially filled (i.e., reclaimed) with native materials in December 2000. Subsequently, alkalinity concentrations about 80 feet downgradient of the reclaimed area increased 270% from 184 mg/L in January 2001 to 680 mg/L in November 2001. About 250 feet downgradient, groundwater showed a 137 % increase in alkalinity from 249 mg/L in January 2001 to 591 mg/L in January 2002. After reclamation occurred, specific conductivity values in the same wells approximately doubled. As of August 2007, alkalinity and specific conductivity values have remained much higher than pre-reclamation values.

Data from groundwater sampling events and in situ monitoring show mine reclamation affected the concentrations of dissolved constituents in groundwater at least 250 feet downgradient from the reclaimed area. Because reclamation affected groundwater conditions within the preserve, it is likely that previous extraction of aggregate materials also affected groundwater conditions within the preserve. These data have been used by INPC to guide management decisions at LITH Fen and other nature preserves where groundwater alterations may affect biota that are protected by law.