ILLINOIS
DEPARTMENT OF NATURAL RESOURCES

Illinois State WATER SURVEY

Ground-Water Availability in Southwestern McLean and Southeastern Tazewell Counties: Project Summary

Illinois Department of Natural Resources — **March 1998**

Background

The drought of 1988-1990, coupled with a growing population in the Bloomington-Normal area, brought attention to the need for a long-range water plan to meet increased water demands. The Long-Range Water Plan Steering Committee (LRWPSC) funded two studies: 1) to evaluate the water needs of communities in the area, and 2) to determine the feasibility of a regional water supply. The second study concluded that regional water needs would be best served by using ground water. In 1993, the LRWPSC funded a study of the sand-and-gravel aquifers in southwestern McLean and southeastern Tazewell Counties to estimate the availability of ground water (Figure 1). That research effort, the topic of this summary, was conducted by the **Illinois State Water Survey** (ISWS) and the **Illinois State Geological Survey** (ISGS), which are divisions of the **Illinois Department of Natural Resources**.

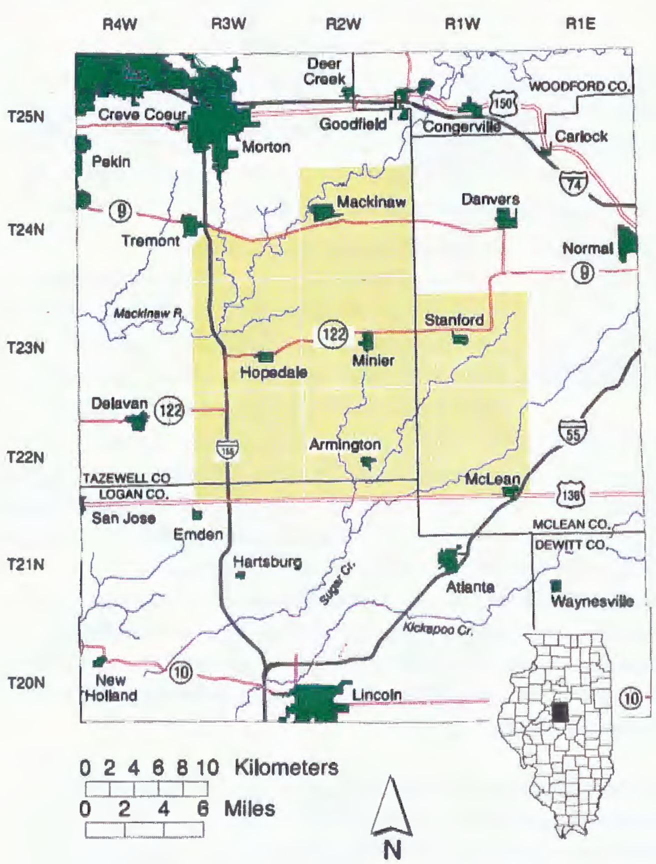

Figure 1. Location of the study area (yellow) within the model area

Conclusions

- The Sankoty–Mahomet Sand aquifer could yield more than 30 mgd to a regional well field if the withdrawals come from areas where the Sankoty-Mahomet Sand aquifer is thick and there is direct connection with overlying shallow aquifers.
- In the four well field simulations, each pumping 15 mgd, maximum drawdown varied from 10 feet at the Hopedale location to 55 feet at the Armington location. Drawdown was 35 feet at the Emden location and 45 feet at the Mackinaw location. Two miles from the well fields, drawdown ranged from 5 feet at the Hopedale location to 40 feet at the Armington location.
- Based on our simulations, the number of wells needing review to determine impacts from pumpage ranges from 0 to 400. Remediating any impacts would require lowering the pump or drilling a new well.

This unique study provides a level of detailed information about the ground-water resources of the area that is unmatched in any other area of the state. The results of this research will provide community leaders and local entities with the knowledge they need to manage this most valuable renewable resource.

Goals

Previous studies estimated that a regional water supply would need to provide 10 to 15 million gallons of water a day (mgd). Such a supply, in addition to providing this quantity of water, should be located to minimize adverse impacts to surrounding wells. To determine if it was possible to meet these requirements, our study had two goals:

1. To determine the quantity of ground water a regional well field could yield.
2. To determine the possible impacts to ground-water levels and to existing wells that might occur from the development of a 10 to 15 mgd well field.

Tasks

Two major tasks were completed to meet the study goals.

- To evaluate and characterize the sand and gravel aquifers. An extensive field effort, which included drilling to determine thicknesses of the sand and gravel aquifers and measuring water levels of those aquifers, provided new data that helped to refine and improve our understanding of the aquifers and the availability of ground water.

- To develop a computer-based, ground-water flow model. The model was used to simulate the effects of hypothetical, 15 mgd well field at four selected locations within the study area. For each tested location, the model tells us the amount of drawdown in the study area. Drawdown is the amount of water-level change caused by pumpage.

Sand-and-Gravel Aquifers

Before glaciers covered Illinois, bedrock (shale, dolomite, limestone, sandstone) was the land surface. Each glacial event deposited sands, gravels, silts, and clays, and formed a new land surface. The current land surface is as much as 400 feet above the bedrock in the study area. The earth materials were deposited in uneven and discontinuous layers, resembling a layer cake. These layers are of two types: sands and gravels that can provide ground water to wells in usable quantities, and clays and silts that do not. For the model, the sand and gravel deposits were assigned to three layers. The clays and silts separate the sand and gravel layers from each other (Figure 2).

As shown in Figure 2, the bottom sand and gravel layer, the Sankoty-Mahomet Sand aquifer, is much thicker and more continuous than those above it. The Sankoty-Mahomet Sand aquifer is a major ground-water resource in central Illinois. It stretches from beyond the Indiana state line to the Illinois River. In our study area, its thickness ranges from zero to more than 150 feet (Figure 3). This is the only aquifer capable of supplying 10 to 15 mgd, and it was, therefore, the focus of our study. Shallower sand-and-gravel layers, which tend to be thin and discontinuous, can provide water for household wells in the study area.

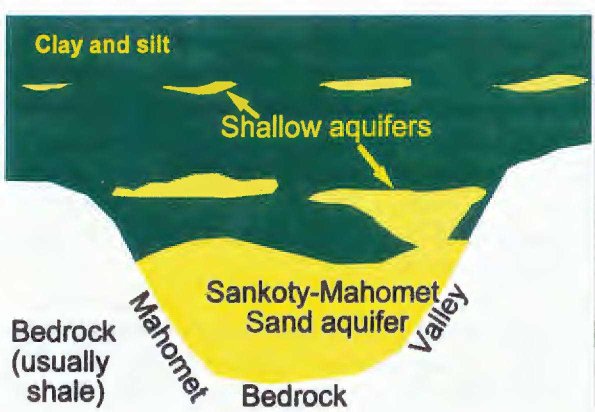

Figure 2. Sequence of earth material

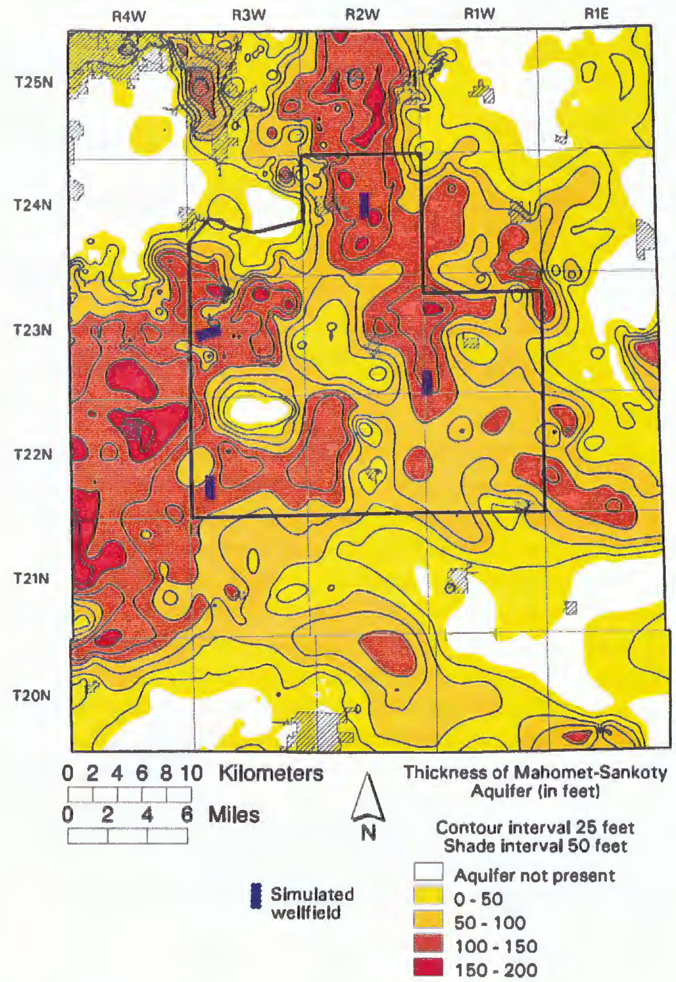

Figure 3. Thickness of Sankoty-Mahomet Sand aquifer. Locations of simulated well fields are in blue.

Ground-Water Flow Model

A ground-water flow model is a mathematical approximation of the "real-world" developed on a computer. For the model, each layer of sand and gravel was mapped over the entire model area and "stacked" to create a three-dimensional picture of the earth materials representative of those found in the model area. The modeling program we used, Visual MODFLOW, is based on well-established and accepted equations of ground-water flow that describe water movement through earth materials. The purpose of the model is to simulate the actual ground-water flow in the study area. By doing this, we can use the computer to "test" hypothetical scenarios to simulate what will happen to water levels in the study area if we pump hypothetical wells in various locations (Figures 4 and 5).

In addition to the sequence of earth materials, model inputs included estimates of pumpage from existing wells, elevations of the water levels, and ease of ground water flow through the layers. Values not measured directly were estimated and adjusted until the model could reasonably duplicate water levels measured in area wells. The model is the best available method that scientists have for achieving the goals of this project.

Results

New data gathered during the field effort and generated by completing the ground-water flow model greatly improved our under-standing of how ground water gets into and moves through the sand-and-gravel aquifers in the study area. In the Sankoty-Mahomet Sand aquifer, we now know that most of the ground water getting into the aquifer drains into it at locations where the clay that separates this aquifer from the shallower aquifers is thin or absent. At these locations, where the "holes" in the clay occur, the Sankoty-Mahomet Sand aquifer is directly connected to shallower aquifers. Updated geologic maps indicated these connections existed, which we were able to verify by analyzing water chemistry data from our observation wells. The chemical analyses revealed that in the areas of the holes, the ground water has a higher percentage of "modern" carbon, an indicator of the relative age of the ground water. In this case, the data indicate that the ground water around the holes is younger than the ground water in other areas of the aquifer. This new understanding gives us more confidence in the validity of the model.

Some ground water also moves into the study area horizontally from the east. Higher water-level elevations to the east cause ground water to flow to the west and north through the study area. The Sankoty-Mahomet Sand aquifer discharges ground water into the Mackinaw River, Sugar Creek and the Illinois River. The connection of the aquifer to the rivers was detectable in the water levels and river stages we measured during the study.

For this study, we chose four locations to test with the ground-water flow model. Many other locations could have been tested. We used the thickness of the Sankoty-Mahomet Sand aquifer as a guide in choosing the locations because the most likely locations for a well field that will minimize drawdown in the surrounding area are those where the

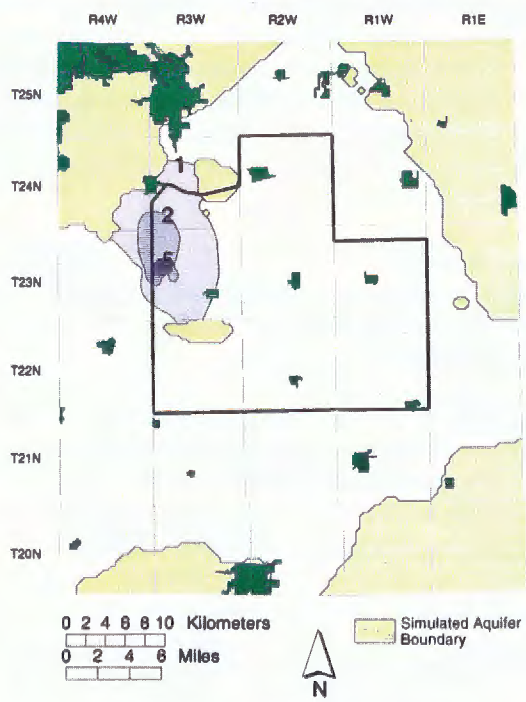

Figure 4. Simulated drawdown at the Hopedale scenario (in feet).

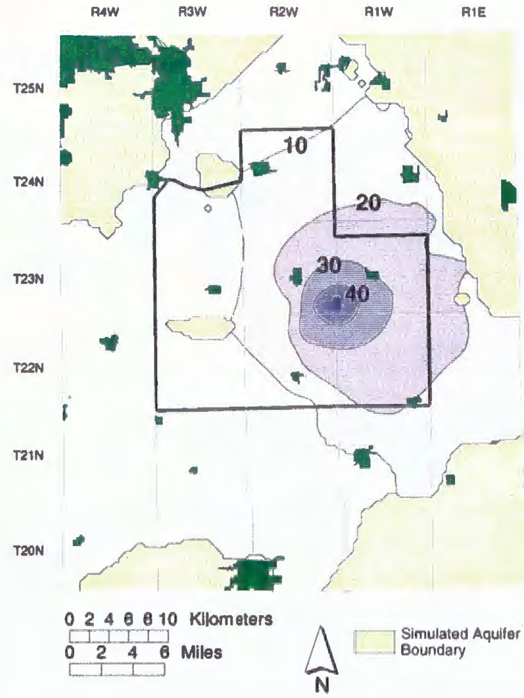

Figure 5. Simulated drawdown at the Armington scenario (in feet).

aquifer is the thickest and/or connected to an overlying shallow aquifer (Figure 3). At each location we simulated a 15 mgd well field. The results of two of the computer simulations are included as maps of drawdown from the hypothetical well field.

The simulation near Hopedale, along the Mackinaw River, had the smallest impacts of the four scenarios. In this simulation, the 10-foot drawdown contour only occurred at the well field because of significant leakage from the Mackinaw River which overlies the aquifer. The 5-foot drawdown contour was 1-2 miles from the well field (Figure 4). We were able to increase the pumpage to 30 mgd and limit the maximum drawdown to less than 20 feet.

The simulation north of Armington, indicated there is more drawdown than at the Hopedale scenario (Figure 5). This is due to the fact that the aquifer is of variable thickness in this area, and the area is not close to a river or other known sources of recharge. The 10-foot drawdown contour was as much as 15 miles from the well field.

The other two scenarios, Emden and Mackinaw, had varying results. Near Emden, the maximum drawdown at the well field was about 35 feet, and the 10-foot drawdown contour was about 6 miles from the well field. Near Mackinaw, the drawdown at the well field was about 45 feet and the 10-foot drawdown contour was about 12 miles from the well field.

Regional Implications

The area we modeled is only part of a much larger aquifer system in the Mahomet Bedrock Valley (Figure 6). Our model results and data from previous studies along the valley suggest that pumpage in other parts of the system, especially just east of the study area, could influence water levels in the study area.

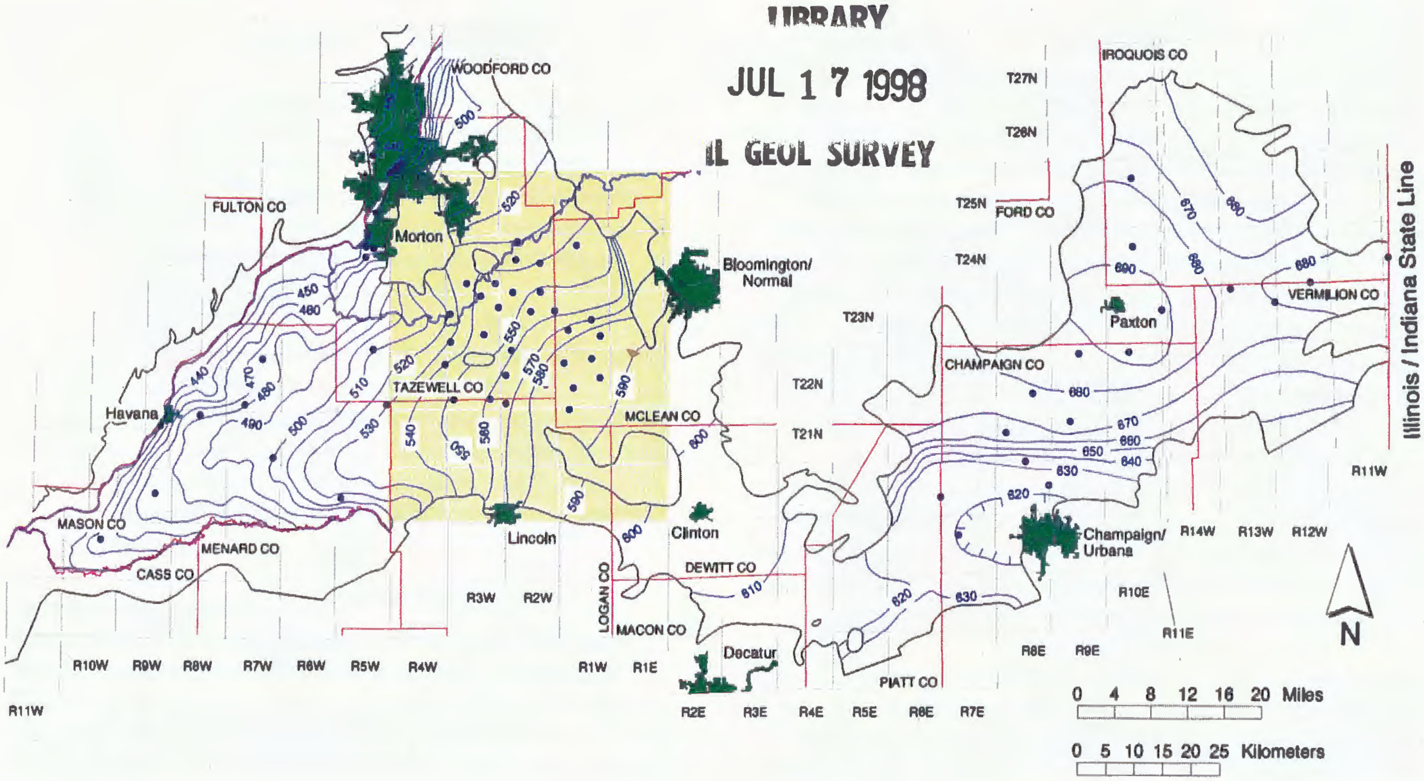

Figure 6. Water-level elevation map of the Sankoty-Mahomet Sand aquifer in the Mahomet Bedrock Valley. Ground-water flow is generally from east (right) to west (left). The model area is shaded yellow.

In Figure 6, the effects of the ground-water withdrawal for Champaign-Urbana can be distinguished by the low water level elevations in that area. This withdrawal, about 18 mgd, is currently the largest withdrawal from the aquifer.

Additional water supply development by other entities outside of the study area, but still within the aquifer, could reduce the potential yield or increase the impacts caused by pumpage in the study area.

Considerations and Recommendations

- Concentrations of naturally occurring arsenic, ammonia, and methane could play a role in the development of a regional water supply. Though most of the rural communities have a sufficient quantity of water for the foreseeable future, changes in water quality standards may make the cost of small-scale treatment very high. If that were to occur, a regional system that includes all of the rural communities may be more practical.

- Water-level data for periods of climatic extremes are necessary for a complete understanding of an aquifer system. Without actual data, we cannot be sure about the amount of water-level change that would occur due to drought. The State Climatologist estimated a recurrence interval for a drought, such as the one in 1988, to be about 50 years. Water levels have been regularly measured in the study area since 1992. This is a very short period of record. Water-level measurements should continue for the foreseeable future.

- The ground-water flow model is a very valuable tool and it must be maintained. To enhance this model, as new information becomes available for the study area (i.e., new pumpage, new well logs containing valuable geologic information), the model should be updated (every 3-4 years). New data improve our understanding of the area. Incorporating this data will produce more reliable answers from our model. This updating is also necessary to ensure that the modeling software is kept up-to-date as computer technology advances. The better we maintain the model, the more representative and useful our model output will be.

Project Reports

The project resulted in two publications, which are available by contacting either the ISWS or the ISGS at (217) 333-8888 or (217) 244-4747.

Herzog, B. L., et al. 1995. *Hydrogeology and Groundwater Availability in Southwest McLean and Southeast Tazewell Counties Part 1: Aquifer Characterization*. Cooperative Report 17. 70 pp. Appendices were published separately.

Wilson, S. D., et al. 1998. *Hydrogeology and Groundwater Availability in Southwest McLean and Southeast Tazewell Counties Part 2: Aquifer Modeling*. Cooperative Report 19 (in preparation).