AQUIFER MAPS FOR COUNTY PLANNERS IN LAKE COUNTY, ILLINOIS: THREE-DIMENSIONAL GEOLOGIC MAPPING, AND AQUIFER SENSITIVITY CLASSIFICATION FOR THE ANTIOCH QUADRANGLE

Barbara J. Stiff, Michael L. Barnhardt, Ardith K. Hansel, and David R. Larson
Illinois State Geological Survey, 615 East Peabody Drive, Champaign, IL 61820, stiff@geoserv.isgs.uiuc.edu

INTRODUCTION

Lake County is located in the northeast corner of Illinois (Fig. 1). Adjacent to the Chicago metropolitan area, it contains some of the most rapidly growing communities in the state. Many of these communities rely heavily upon groundwater resources. Accurate maps of the sands and gravels within the thick Quaternary sediments are needed by agencies of local government for infrastructure planning, resource development (potential aquifers, recharge areas, building aggregate, etc.), land use planning, and environmental protection.

Current Illinois State Geological Survey (ISGS) mapping projects in northeastern Illinois (e.g., Central Great Lakes Geologic Mapping Coalition, STATEMAP) are addressing key questions as to the origin and distribution of the glacial deposits and creating products that show the complexity and variability of the succession of materials above bedrock (Barnhardt et al., 2003). To achieve these goals, geologists are using modeling software to integrate water well records, geophysical logs, and borehole data to produce 3-dimensional models and detailed (1:24,000 scale) geologic maps that show the complex geometry of sands and gravels (aquifer materials) and fine-grained sediments (aquitards) in the subsurface.

The county is overlain by a thick (mostly >250ft/80m) succession of Quaternary deposits that resulted from the multiple glacial advances of the last glaciation. Each time glaciers of the Lake Michigan lobe advanced out of and retreated into the Lake Michigan basin a ‘layer-cake’ of glacial, fluvial, and lacustrine materials was deposited. Because the ice from earlier advances did not completely melt from the area before subsequent ice advanced, the sediment layers were modified by dead-ice sedimentation during deglaciation.

THE MODEL

The mapping team acquired, verified, and interpreted drilling records and/or gamma logged the sediments from over 5,000 borings in and around the Antioch Quadrangle. Available water wells and engineering borings (3,036), detailed records from ISGS study-specific drilling (9), natural gamma logs from both new and old boreholes (36), shallow seismic reflection transects (2), and a few outcrop and/or exposure descriptions from gravel pits and construction excavations were reviewed.

The 3-D lithostratigraphic model is based on a selected subset of 352 records, 283 within the quadrangle boundary and an additional 69 records within a 1-mile buffer adjacent to the quadrangle (Hansel, 2005). Wells were selected on the basis of location accuracy, geographic distribution, total depth, and quality of the description of materials found in the well. The hydrostratigraphic model used an additional 110 wells.

For the lithostratigraphic model, the Quaternary materials were grouped into units that represent sediment layers that have a distinct lithology and stratigraphic position and represent different sedimentary environments. The present model includes 11 units (Fig. 2). There are 5 layers of sorted sediment (in shades of yellow) and 6 layers of fine-grained materials (in shades of green). The model displays the geometry and relationships of the sediment layer.
For the hydrostratigraphic model, Quaternary materials were assigned to one of 12 units based on hydrogeologic properties of the materials described and their position in the driller’s logs and the static water levels reported in the water-well records. This model will be used to 1) evaluate the aquifer and aquitard units; 2) determine patterns of groundwater flow; and 3) assess both the availability of groundwater and the potential for groundwater contamination.

Figure 2. Lithostratigraphic Model of the Antioch Quadrangle (modified from Hansel, 2005).

AQUIFER RISK MAP

Elevation grids from the lithostratigraphic units were exported to ArcInfo software for visualization and map development. The upper and lower surface grids for each sand and gravel unit (aquifer) were converted to isopachous coverages, coded for elevation, and unioned. Unit thickness was calculated by subtracting the lower elevation from the upper. Similarly, depth-to (cover thickness) distances for each unit were calculated by subtracting the upper surface elevation from land-surface topographic elevations.

The aquifer risk map for each sand and gravel unit (Fig. 3) was produced by joining the unit and depth-to-thickness files and coding the polygons using the Aquifer Sensitivity Classification for Illinois (Berg, 2001). This classification scheme includes 6 classes (A through F) of decreasing sensitivity based on the potential for contaminant movement through aquifer materials and their proximity to land surface (Berg et al., 1984). The unit risk maps were unioned into a single coverage. Individual thickness, unit surface elevation, depth-to, and contamination fields were carried into the composite coverage to maintain extractable unit data from the whole.

PROXIMITY MAP

This preliminary map displays proximity of ‘fairly clean’ glaciofluvial materials to land surface (Fig. 4). The map was derived from the hydrostratigraphic model and is an adjunct to the Aquifer Sensitivity Map. It displays some variation in the distribution and geometry of aquifer materials as a result of the different classification of certain sorted sediments on
Figure 3. Steps used to develop the Antioch Quadrangle Aquifer Risk Map. Each and gravel layer was converted to thickness and elevation files and coded according to Aquifer Sensitivity (Berg, 2001).
the basis of their hydrogeologic properties. For example, materials containing the term ‘fine sand’ were grouped with aquifer materials in the hydro-model but were grouped with fine-grained sediments in the litho-model.

The materials from some wells were difficult to categorize because there was insufficient information to determine hydrologic properties. Compound descriptions such as ‘gravel and clay’, ‘silt and sand’, ‘clay and gravel’, etc. were included with fine-grained. However, the potential for water movement within these materials clearly exists.

Figure 4. Proximity of Aquifer Materials to Land Surface Map. The colors represent depth to sand and gravel from land surface. Values increase from magenta (shallow) to red-orange (deep) in 10 foot increments. Distinct color shifts in the image include 30 to 40 feet (dark blue), 110-120 (cyan), 230-240 (yellow), up to 300 to 310 in the thickest areas.

REFERENCES


