Groundwater Occurrence & Movement:
An Introductory Discussion with Application to Northeastern Illinois

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Topical Presentation Outline

Basic Concepts and Definitions

- The Hydrologic Cycle
  What is groundwater?

- Concepts & Definitions
  Porous Flow vs. Fractured Flow
  Aquifers vs. Aquitards
  Artesian vs. Water Table Conditions

- Regional Groundwater Flow Systems

- Well & Aquifer Hydraulics

- Groundwater Modeling
The Hydrologic Cycle

Climate, surface water, and groundwater are linked
Porous Systems

Groundwater flows through pore spaces between grains.
## Porosity & Effective Porosity Ranges

<table>
<thead>
<tr>
<th>Material</th>
<th>Porosity (%)</th>
<th>Eff. Porosity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silt</td>
<td>34 - 61</td>
<td>0.1 - 10</td>
</tr>
<tr>
<td>Clay</td>
<td>34 - 60</td>
<td>0.1 - 10</td>
</tr>
<tr>
<td>Sand/Gravel</td>
<td>24 - 55</td>
<td>10 - 55</td>
</tr>
<tr>
<td>Limestone/dolomite</td>
<td>5 - 15</td>
<td>0.1 - 5</td>
</tr>
<tr>
<td>Shale</td>
<td>1 - 10</td>
<td>0.5 - 5</td>
</tr>
<tr>
<td>Sandstone</td>
<td>5 - 15</td>
<td>0.5 - 10</td>
</tr>
</tbody>
</table>
Fractured Systems
Fractured Limestone or Dolomite
Aquifers vs. Aquitards

An **aquifer** is a saturated bed, formation, or group of formations which yields water in sufficient quantity to be of consequence as a source of supply.

An **aquitard** yields *inappreciable* quantities of water to wells compared to an aquifer but through which *leakage* of water is possible. Aquitards often act as confining beds.
Unconfined vs. Confined Groundwater

An *unconfined* aquifer is one in which groundwater possesses a free surface open to the atmosphere. The upper surface of the zone of saturation is called the *water table*.

A *confined* aquifer is one in which groundwater is confined under pressure by overlying and underlying aquitards or aquicludes and water levels in wells rise above the top of the aquifer. Also called an *artesian* aquifer.
Unconfined Aquifers

- Land Surface
- Unconfined Aquifer
- Bedrock
- Water Table
- Unsaturated (Vadose) Zone
- Saturated Zone
Confined Aquifers

- Land Surface
- Unconfined Aquifer
- Water Table
- Bedrock
- Unsaturated (Vadose) Zone
- Water Table
- Saturated Zone
- Confined Aquifer
- Confining Layer - Aquitard
- Potentiometric Surface
- Bedrock
Confined Aquifers & Artesian Wells

- Flowing artesian well
- Land surface
- Water table
- Aquifer
Regional Groundwater Flow Systems

- 0.1 mile
- 20 miles

Depth
- 0'
- 100'
- 200'
Groundwater – Stream Interaction

Regional Flow Systems
Groundwater – Stream Interaction

Regional Flow Systems
Groundwater – Stream Interaction
Groundwater – Stream Interaction

Regional Flow Systems
## Groundwater Flow Velocities

<table>
<thead>
<tr>
<th>Material</th>
<th>Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>5-10 feet per day</td>
</tr>
<tr>
<td>Clean sand</td>
<td>1 - 5 feet per day</td>
</tr>
<tr>
<td>Clayey sand</td>
<td>0.1 – 0.5 feet per day</td>
</tr>
<tr>
<td>Clay</td>
<td>&lt; 0.1 feet per day</td>
</tr>
<tr>
<td>Sandstone</td>
<td>&lt; 0.5 feet per day</td>
</tr>
<tr>
<td>Highly fractured limestone</td>
<td>10 – 1000’s feet per day</td>
</tr>
</tbody>
</table>
Quaternary Deposits of Illinois

Hudson and Wisconsin Episodes
Mazon Group and Cahokia Fm
- Cahokia and Henry Fms: sorted sediment including waterlain river sediment and windblown and beach sand
- Equality Fm: fine-grained sediment deposited in lakes

- Thickness of Peoria and Roxana Silt, tills deposited at less than 5 feet contour interval

Wedron Group (Trumana, Lemont, and Waldworth Fms) and Traftargar Fm; diamicton deposited as till and ice-marginal sediment
- End moraine
- Ground moraine

Illinois Episode
- Wemahago Fm; diamicton deposited as till and ice-marginal sediment
- Glastford Fm; diamicton deposited as till and ice-marginal sediment
- Trenlicate Silt and Pearl Fm, including Hagarstown Mire, sorted sediment including river and lake deposits and wind-blown sand

Ye-Illinois Episodes
- Wolf Creek Fm; predominantly diamicton deposited as till and ice-marginal sediment

Neozoic, Mesozoic, and Cenozoic
- Mostly Paleozoic shale, limestone, dolomite, or sandstone; exposed or covered by loess and/or residuum

Illinois State Geological Survey Bulletin 104, plate 1
Archived from Willman and Frye (1970) and Limbeck (1979)

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by the authority of the State of Illinois (1966/2001)
Glacial depositional processes
Regional Bedrock Topography

Green = higher elevations; Light violet = lower elevations
Major Sand & Gravel Aquifers
Withdrawals from Sand and Gravel Aquifers

Total use ~ 350 mgd
+ ~200 mgd for irrigation
Aquifers of Northeastern Illinois

Unconsolidated Aquifer System
Shallow Bedrock Aquifer
Deep Bedrock Aquifer System
Elmhurst-Mt. Simon Aquifer

Cross-Section Modified from Bretz (1939)
Major Shallow Bedrock Aquifers
Withdrawals from Shallow Bedrock Aquifers

Total use > 200 mgd
Major Deep Bedrock Aquifers
Withdrawals from Deep Bedrock Aquifers

Total use ~ 100 mgd
Cone of Depression

Well/Aquifer Interactions
Overlapping Cones of Depression

Well/Aquifer Interactions
Well/Aquifer Interactions

Overlapping Cones of Depression – Well Interference
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NE Illinois Deep Bedrock Withdrawals, 1900-2000

Estimated Practical Sustained Yield (Ideal Well Distribution) = 65 mgd

182.9 mgd (1979)

71.9 mgd (2000)

Estimated Practical Sustained Yield (1958 Well Distribution) = 46 mgd
Distribution Of Deep Bedrock Aquifer Pumpage

Source: Jaffe
Potentiometric Surface of the Deep Bedrock Aquifer System, Fall 2000
Deep Well Water Levels, Cook County

- Title of the graph:
  - Elevation above Sea Level (feet)

- Data points:
  - CCK 39N 12E-11.7f
  - Maywood

- Time period:
  - 1940 to 2000

- Trend observed:
  - Decreasing trend from 1940 to around 1980
  - Steady decrease until 1990
  - Increase from 1990 to 2000
Water Sources for Public Supply in Northeastern Illinois

*Groundwater is also used within these areas in some cases.
Source: Chicago Metropolitan Agency for Planning
Groundwater Flow Modeling: NE Illinois Regional Model Grid

- 226 rows
- 174 columns
- 18 layers
- 707,832 nodes
- Minimum grid spacing of 2500’
- Maximum grid spacing of 80,000’
Modeled Heads in upper Galena-Platteville - 2002
Modeled Heads in lower Galena-Platteville - 2002
Modeled Heads in Ancell (St. Peter) - 2002
Modeled Heads in Ironton-Galesville - 2002
Thanks!

Look for more information and updates:
http://www.sws.uiuc.edu/wsp

E-mail me with questions:
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