
Groundwater Occurrence & Movement: *An Introductory Discussion with Application to East-Central Illinois*

East-Central Illinois Regional Water Supply Planning Committee
July 27, 2007

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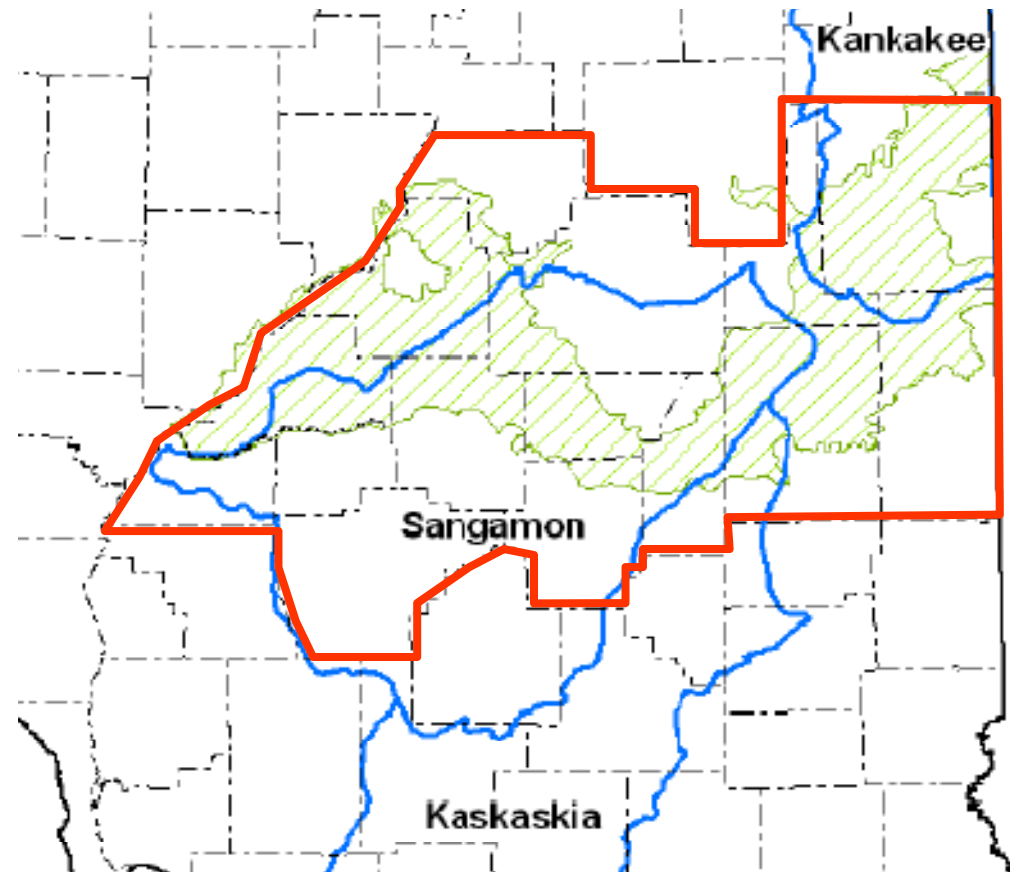
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Hydrogeology Section
Illinois State Geological Survey

Steve Burch & George Roadcap, Ph.D.
Center for Groundwater Science
Illinois State Water Survey



East-Central Illinois Water Supply Planning Area



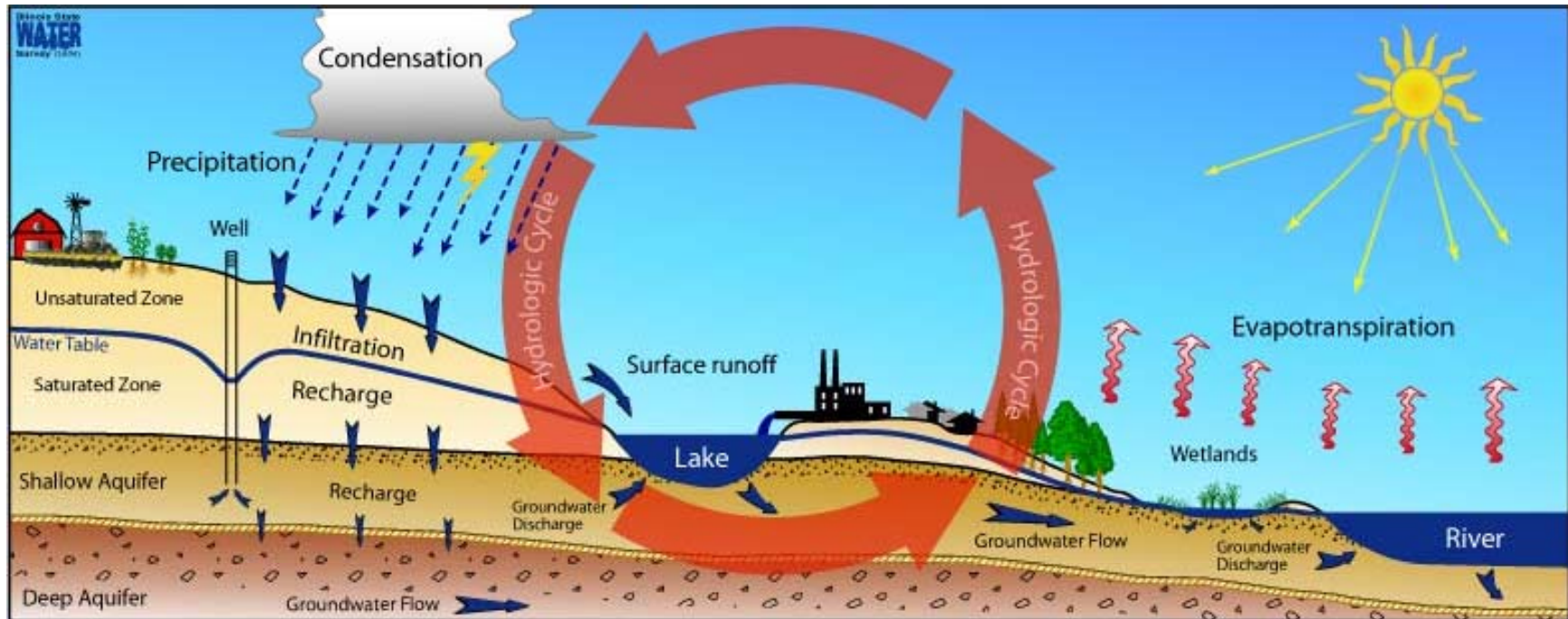
Topical Presentation Outline

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**

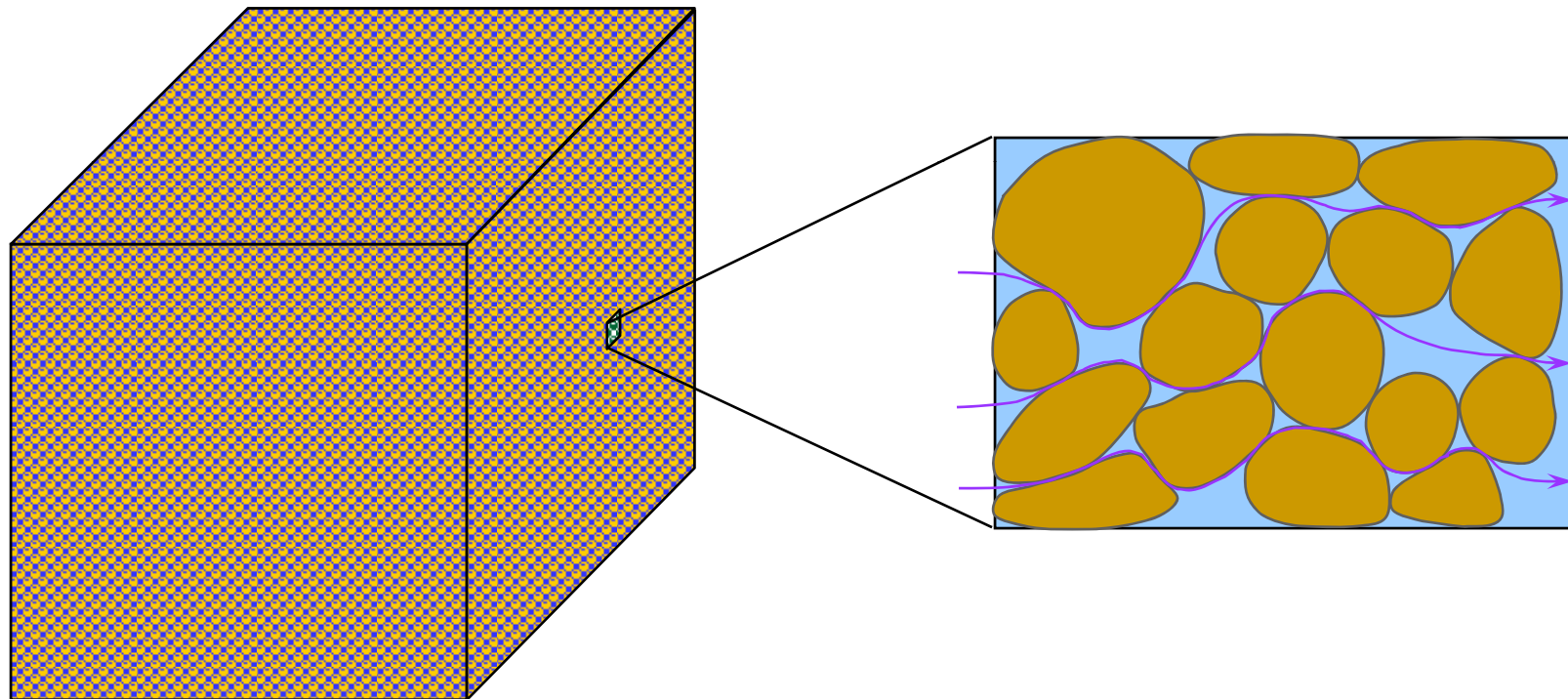
The Hydrologic Cycle

Climate, surface water, and groundwater are linked

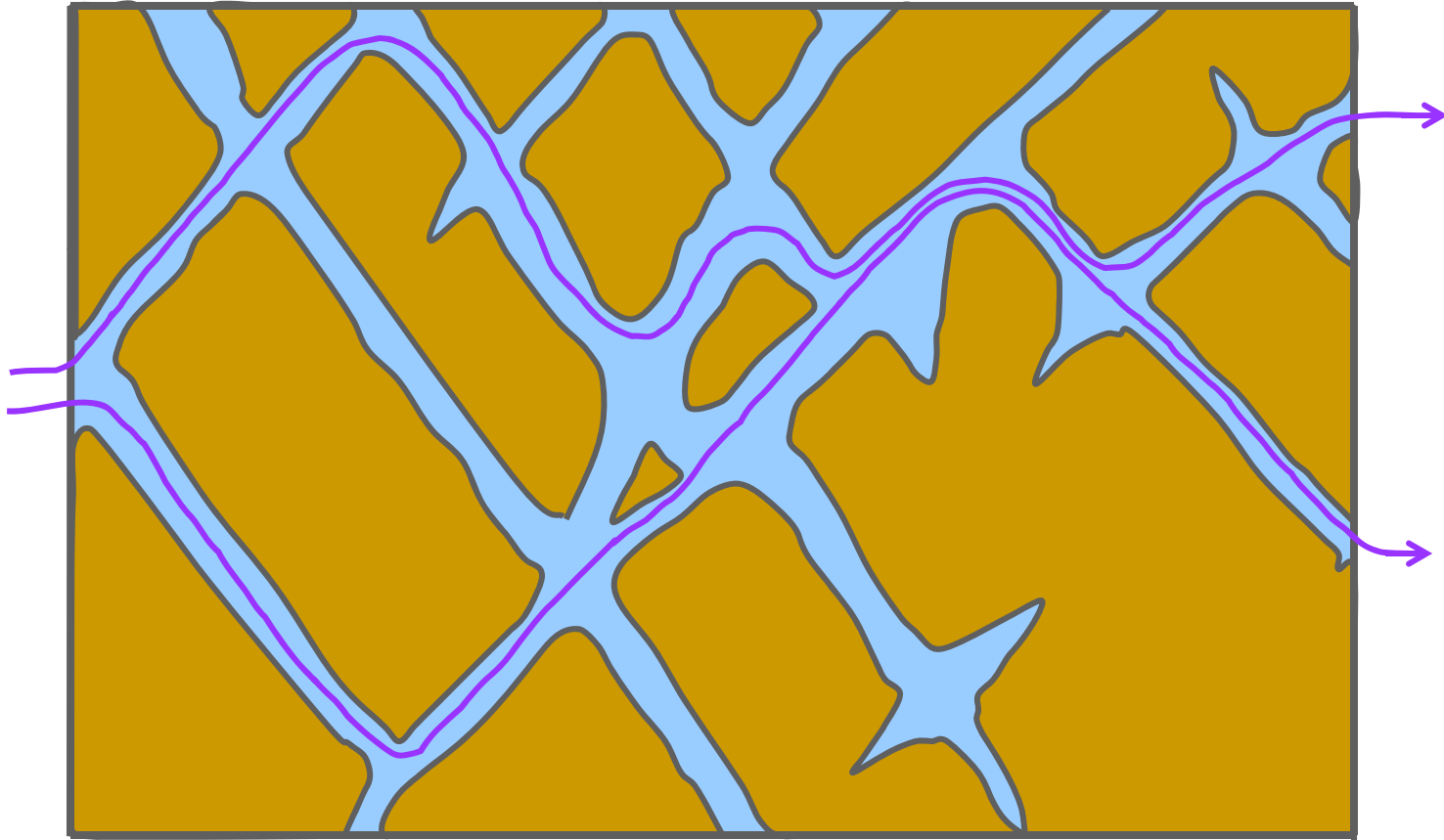


Porous Systems

Porosity = volume of pore space / total volume of porous material



Fractured Systems





Fractured Limestone or Dolomite

Porosity & Effective Porosity Ranges

Material	Porosity (%)	Eff. Porosity (%)
Silt	34 - 61	0.1 – 10
Clay	34 - 60	0.1 – 10
Sand/Gravel	24 – 55	10 - 55
Limestone/dolomite	5 - 15	0.1 – 5
Shale	1 - 10	0.5 – 5
Sandstone	5 - 15	0.5 – 10

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.

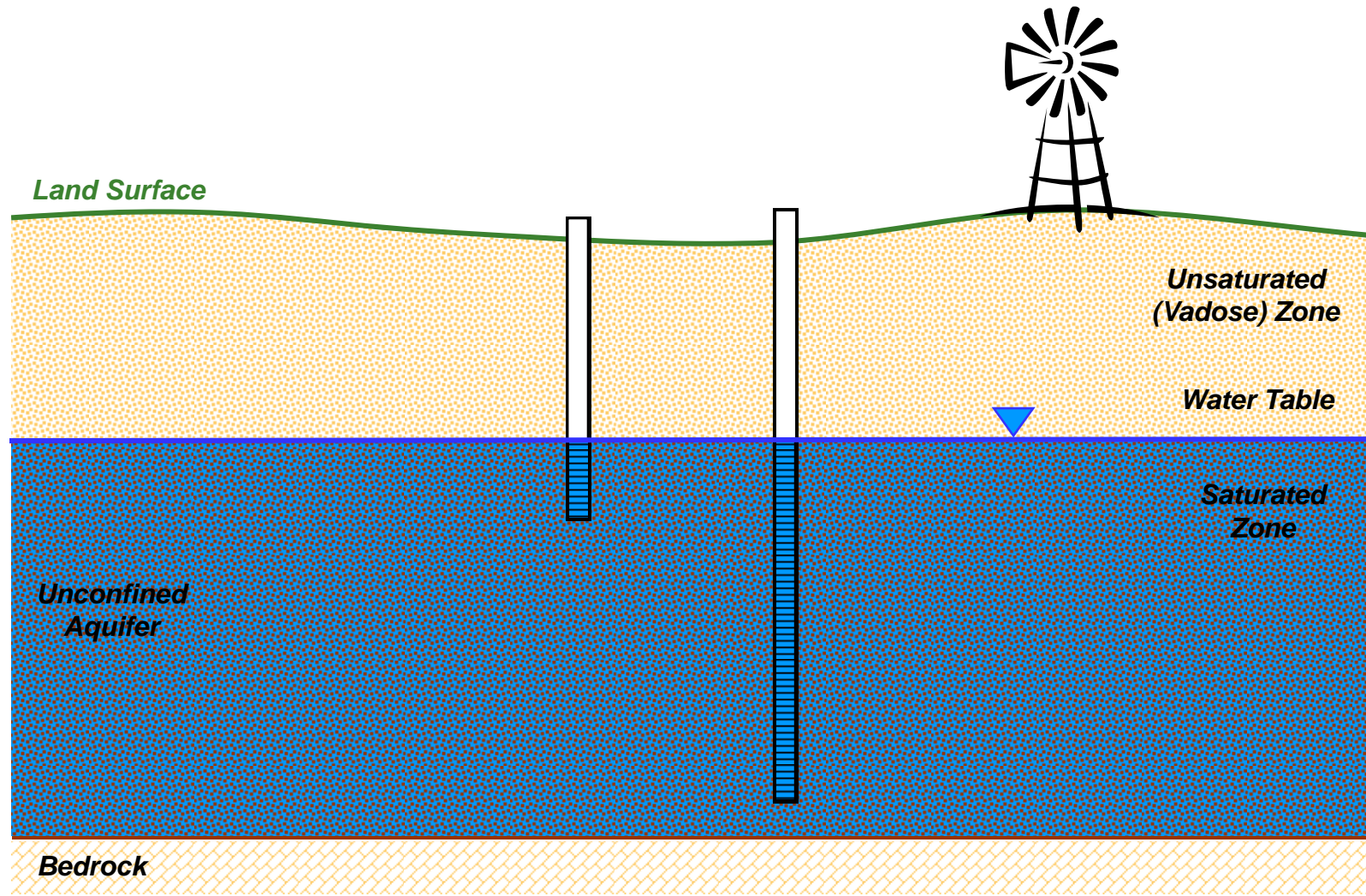
An **aquitard** yields *inappreciable* quantities of water to wells compared to an aquifer but through which *leakage* of water is possible. Aquitards often act as confining beds.

Unconfined vs. Confined Groundwater

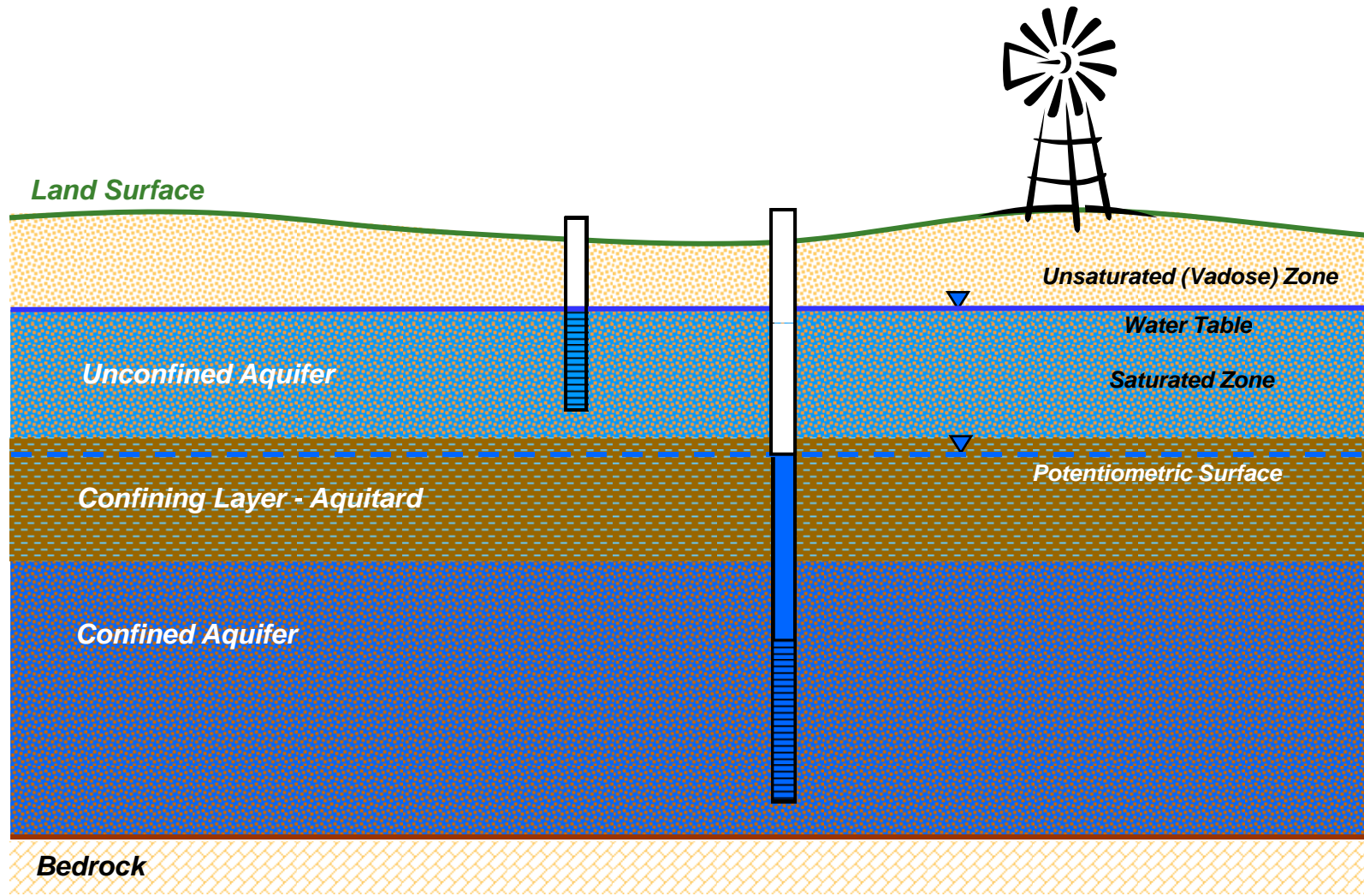
An **unconfined** aquifer is one in which groundwater possesses a free surface open to the atmosphere. The upper surface of the zone of saturation is called the **water table**.

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.

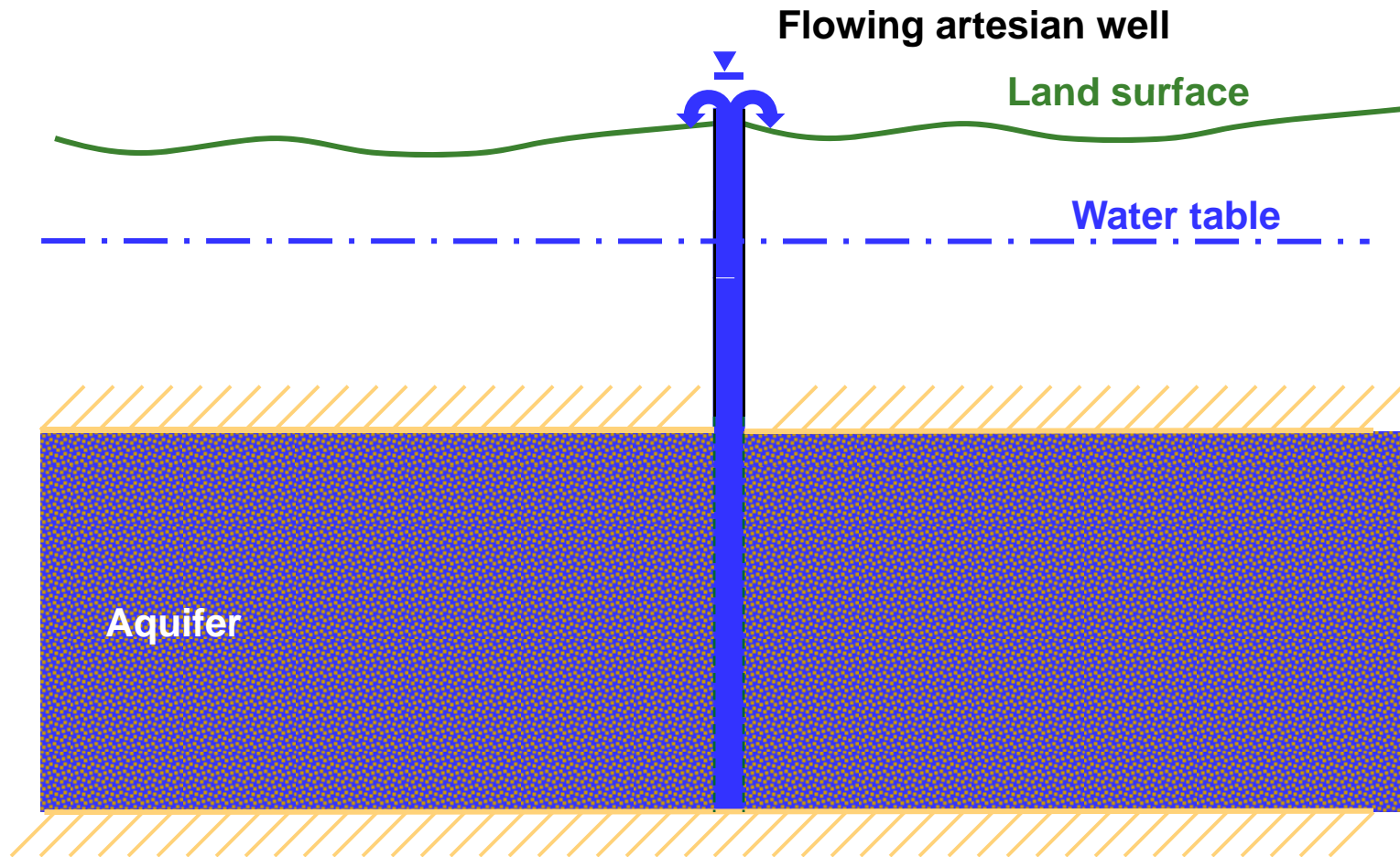
Unconfined Aquifers



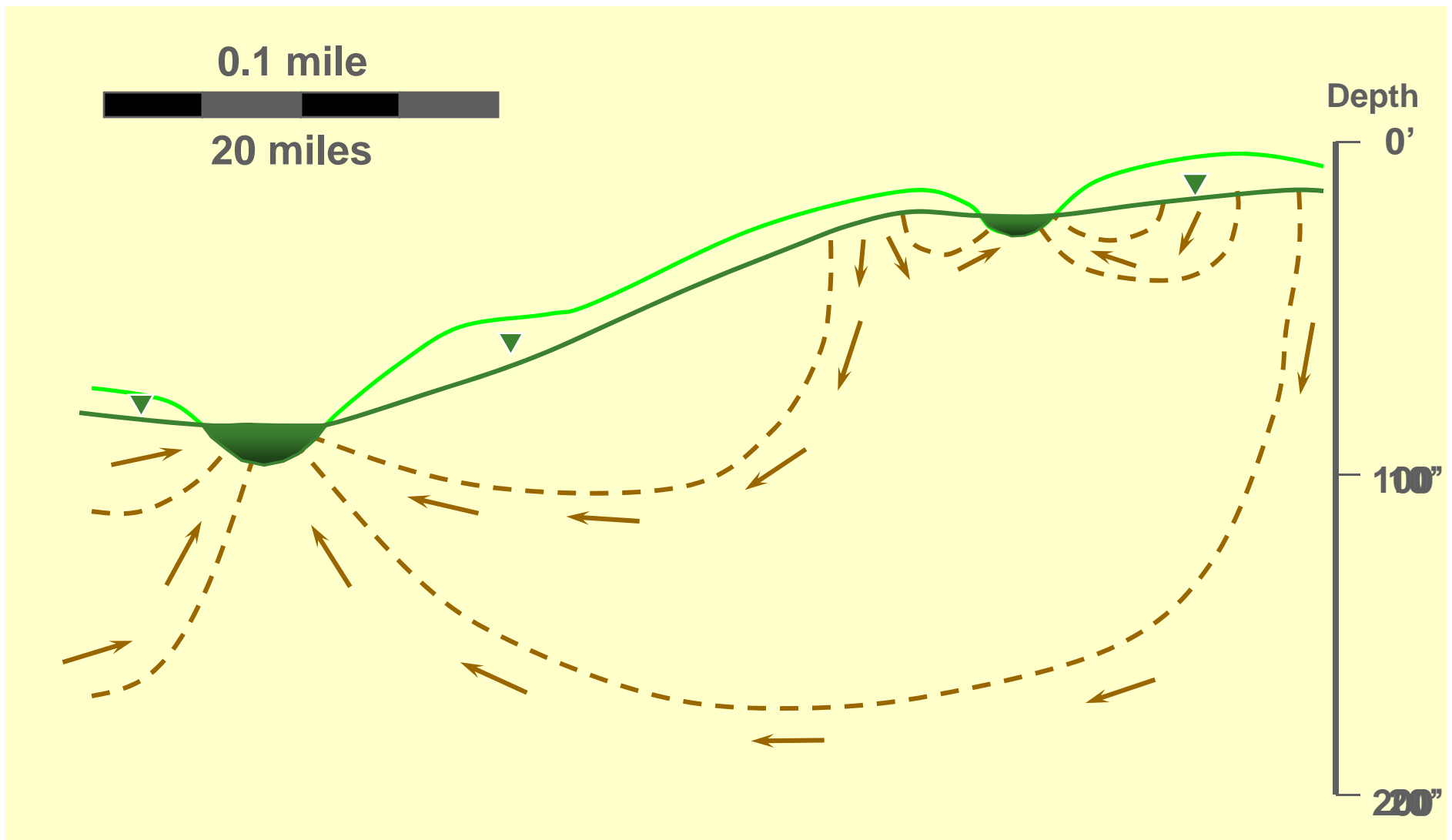
Confined Aquifers



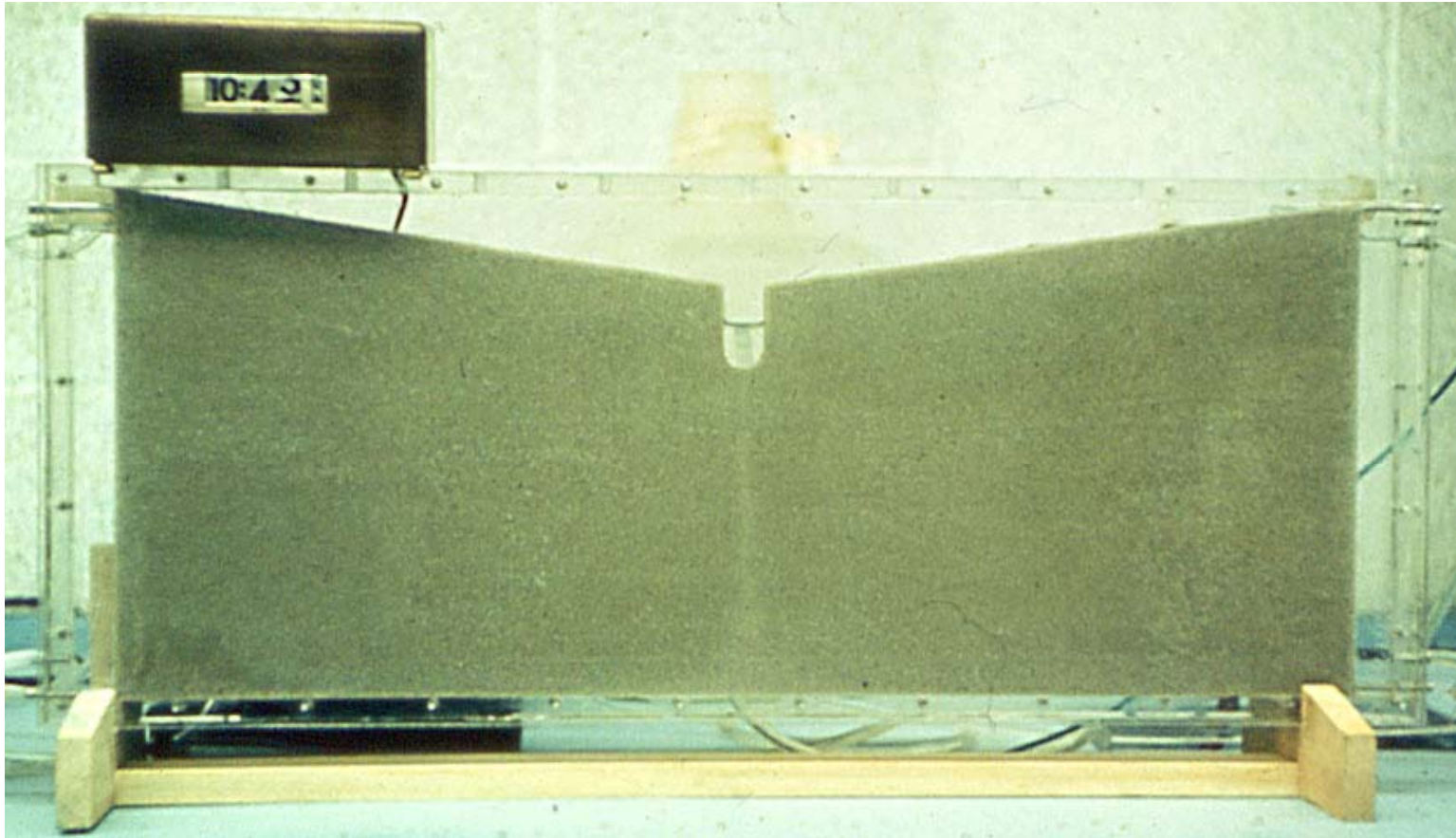
Confined Aquifers & Artesian Wells



Regional Groundwater Flow Systems



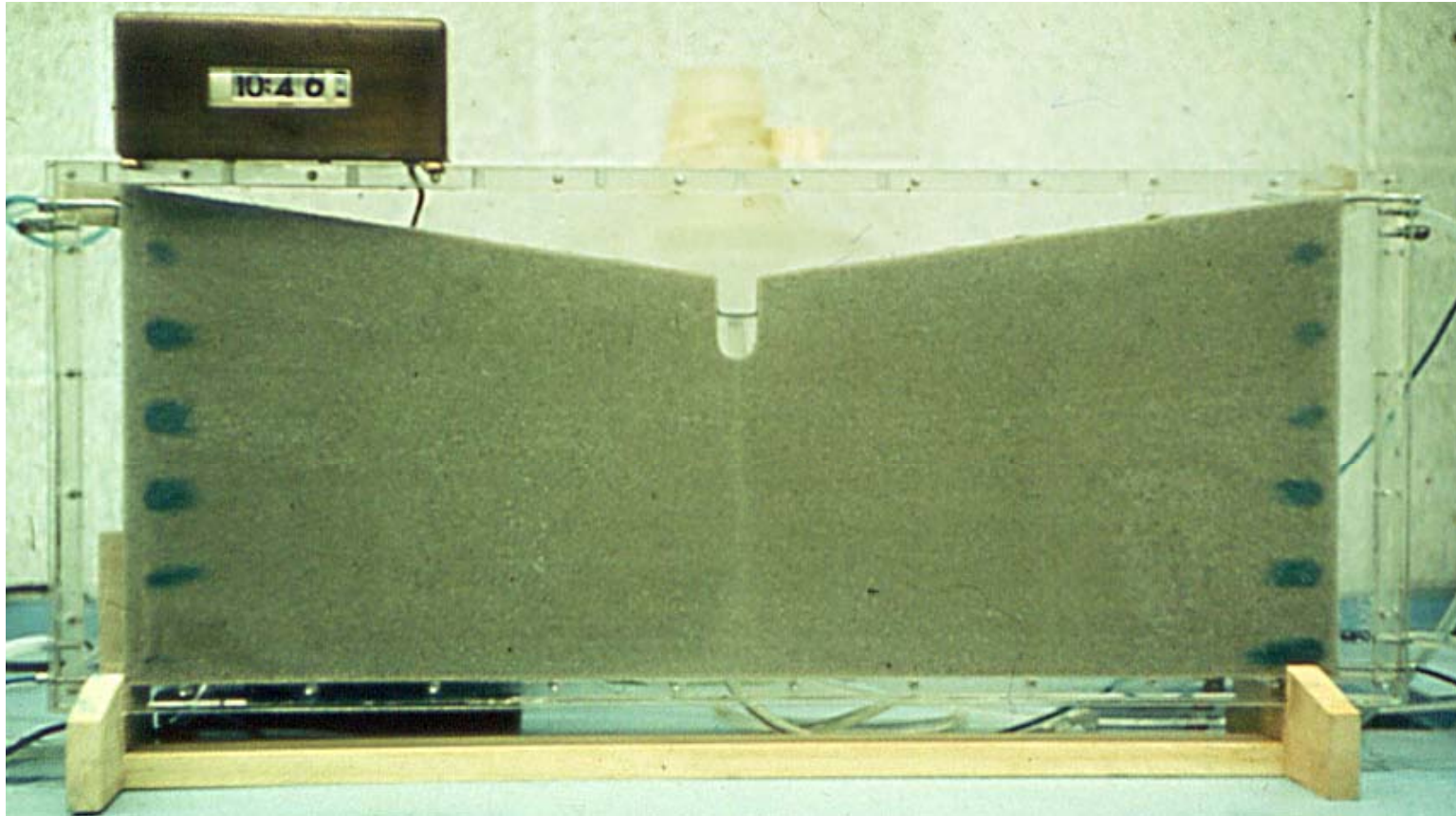
Groundwater – Stream Interaction



Regional Flow Systems



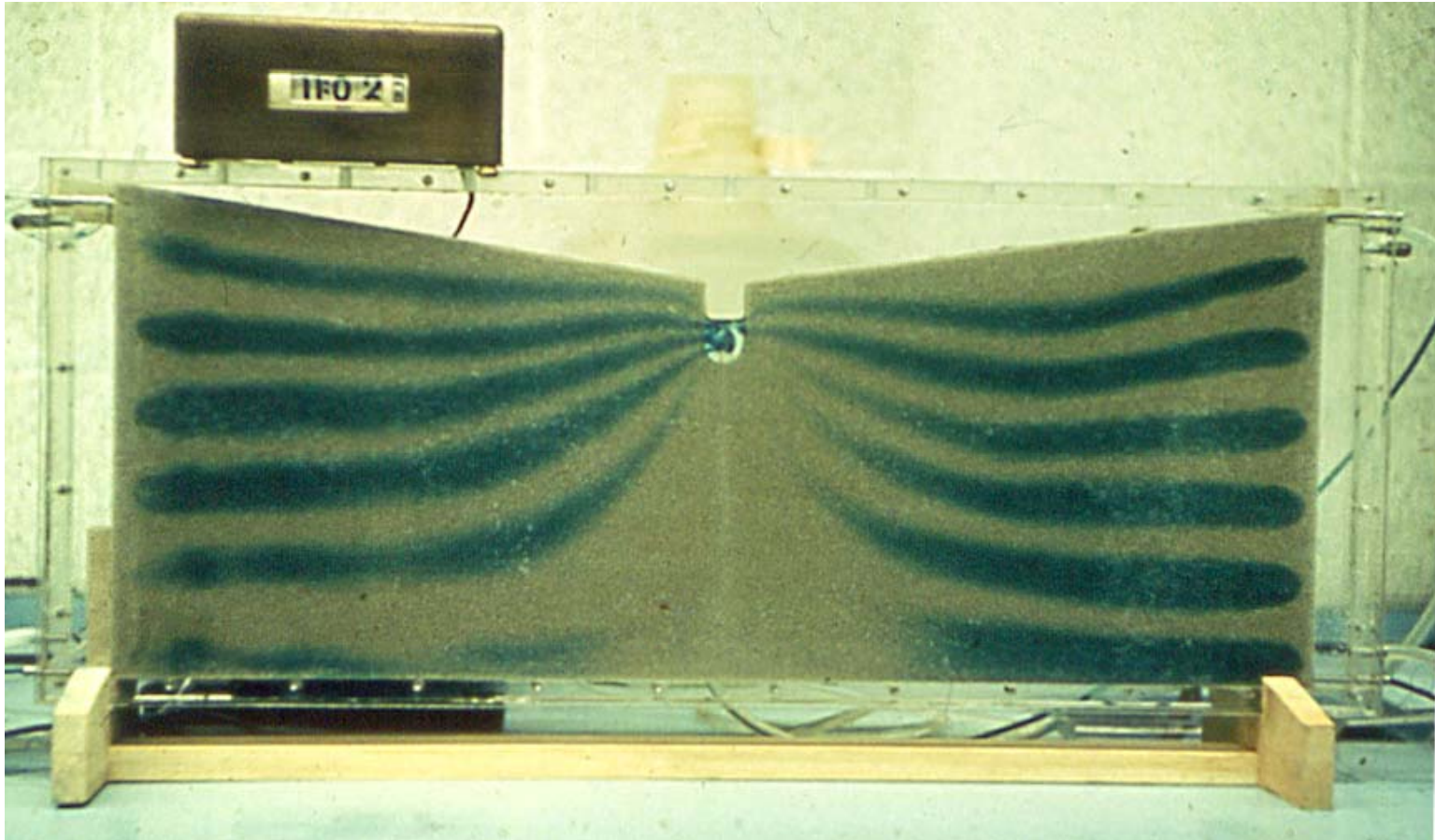
Groundwater – Stream Interaction



Regional Flow Systems



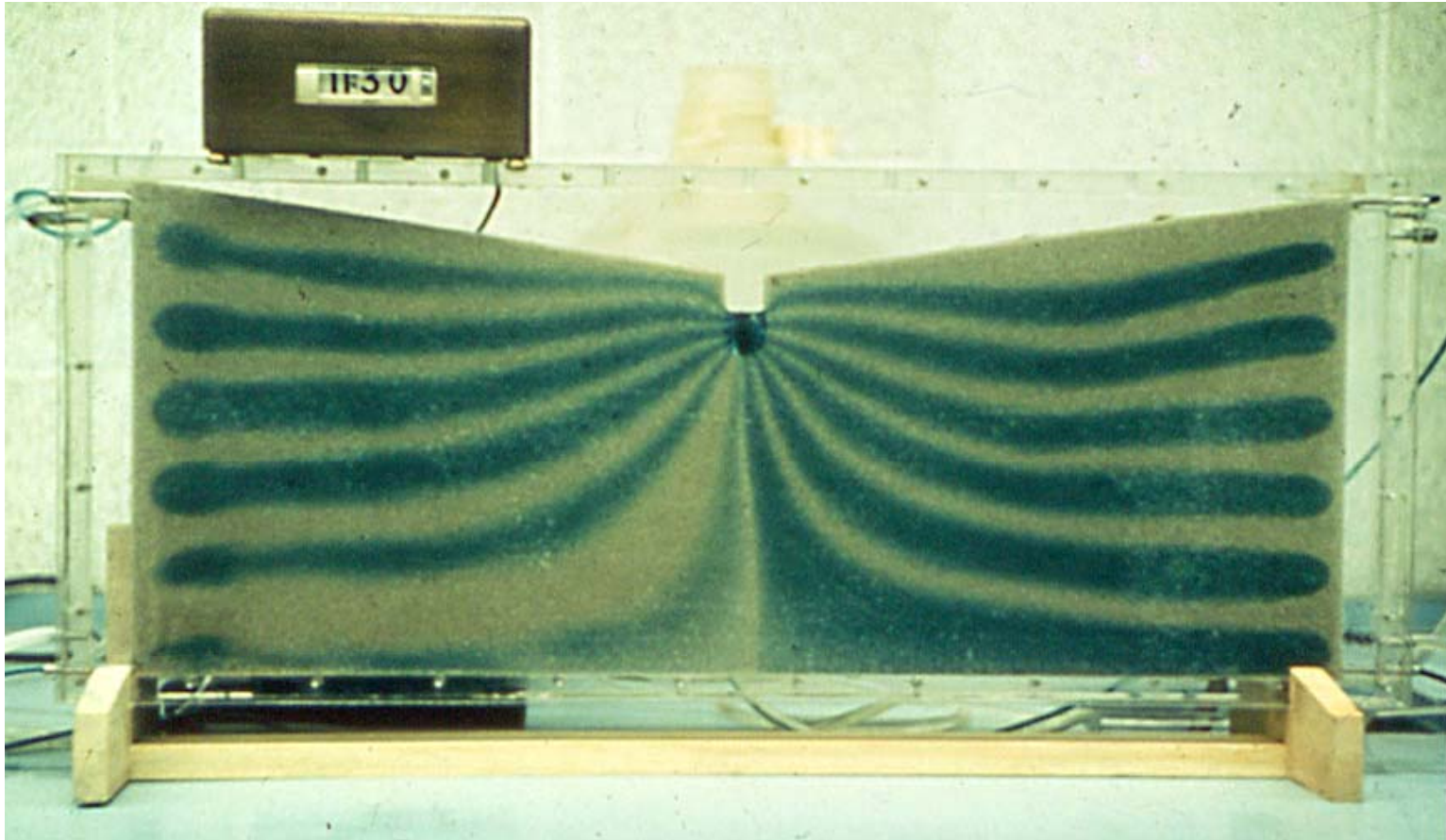
Groundwater – Stream Interaction



Regional Flow Systems



Groundwater – Stream Interaction



Regional Flow Systems



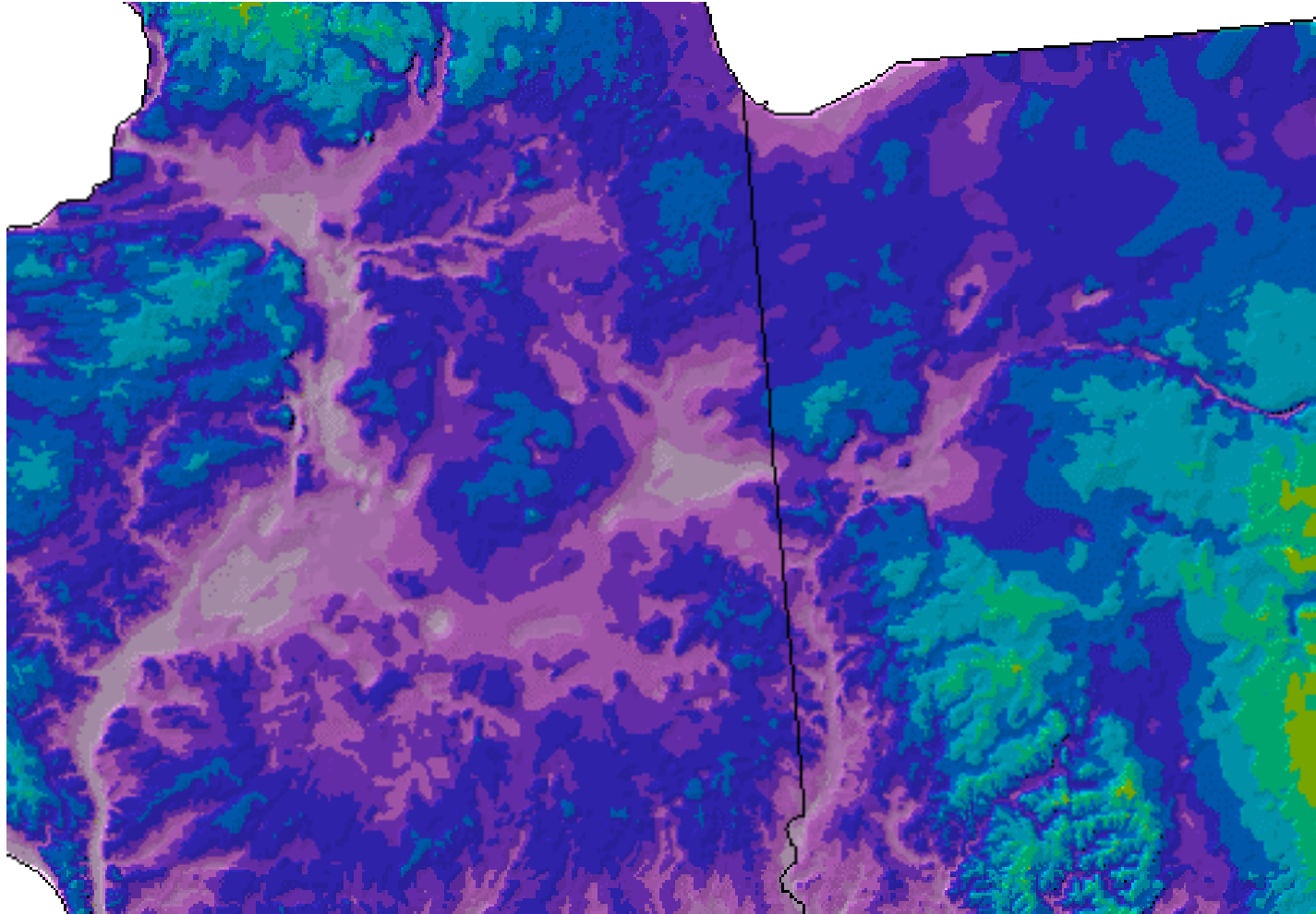
Groundwater Flow Velocities

Material	Velocity
Gravel	5-10 feet per day
Clean sand	1 – 5 feet per day
Clayey sand	0.1 – 0.5 feet per day
Clay	< 0.1 feet per day
Sandstone	< 0.5 feet per day
Highly fractured limestone	10 – 1000's feet per day

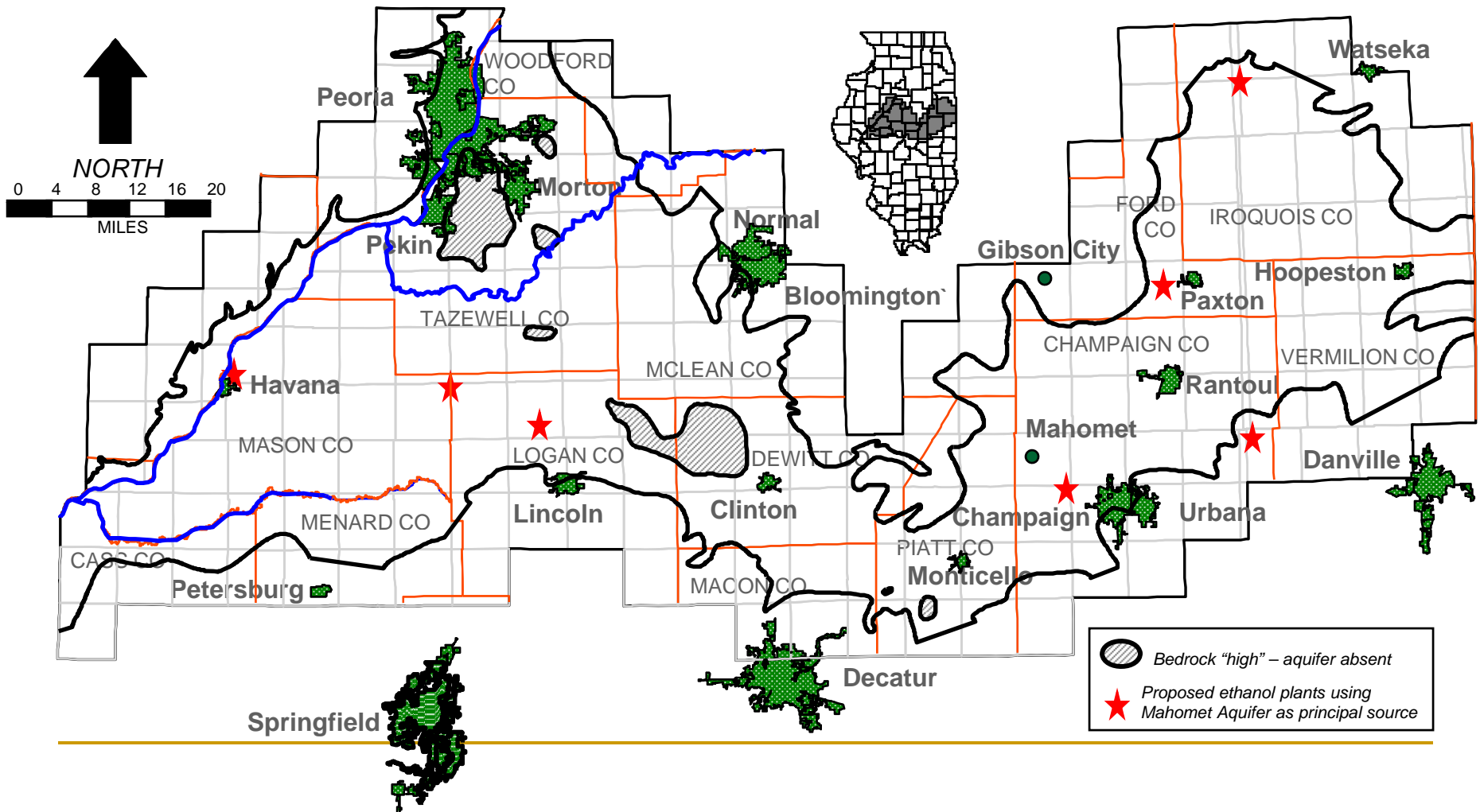
Regional Bedrock Topography

Green= higher elevations

Light violet= lower elevations



The Mahomet Aquifer Region






Illinois Geology: glacial materials

Quaternary Deposits of Illinois

revised by
Ardith K. Hansel and W. Hilton Johnson
1996

Hudson and Wisconsin Episodes

Mason 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 Silts; silt deposited as loess (5-foot contour interval)


Wedron Group (Tiskilwa, Lemont, and Wadsworth Fms) and Traftalgar Fm; diamicton deposited as till and ice-marginal sediment

-  End moraine
-  Ground moraine


Illinois Episode

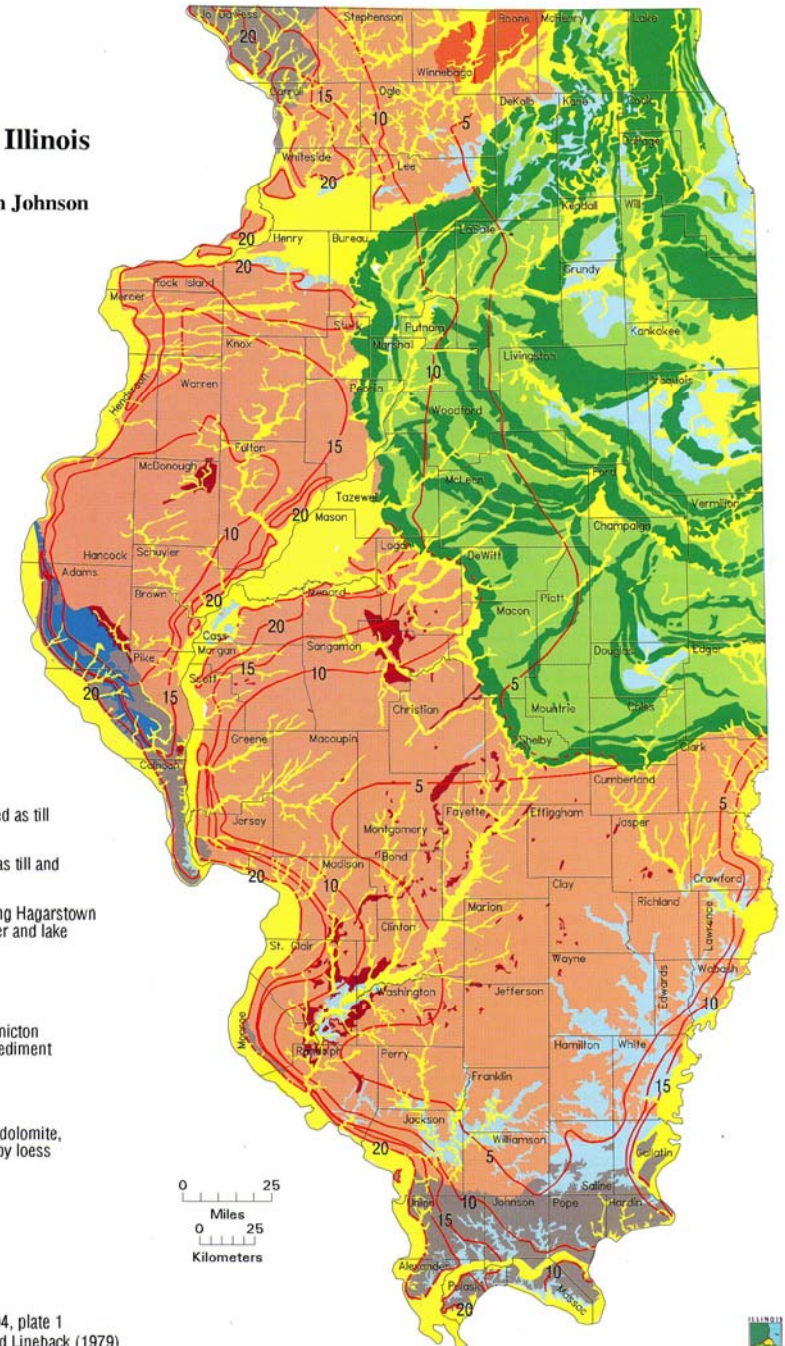
-  Winnebago Fm; diamicton deposited as till and ice-marginal sediment
-  Glasford Fm; diamicton deposited as till and ice-marginal sediment
-  Teneriffe Silt and Pearl Fm, including Hagarstown Mbr; sorted sediment including river and lake deposits and wind-blown sand

Pre-Illinois Episodes

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

Paleozoic, Mesozoic, and Cenozoic

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



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revised from Willman and Frye (1970) and Lineback (1979)
digital compilation by B.J. Stoff

Approved by the authority of the State of Illinois/1996/3000



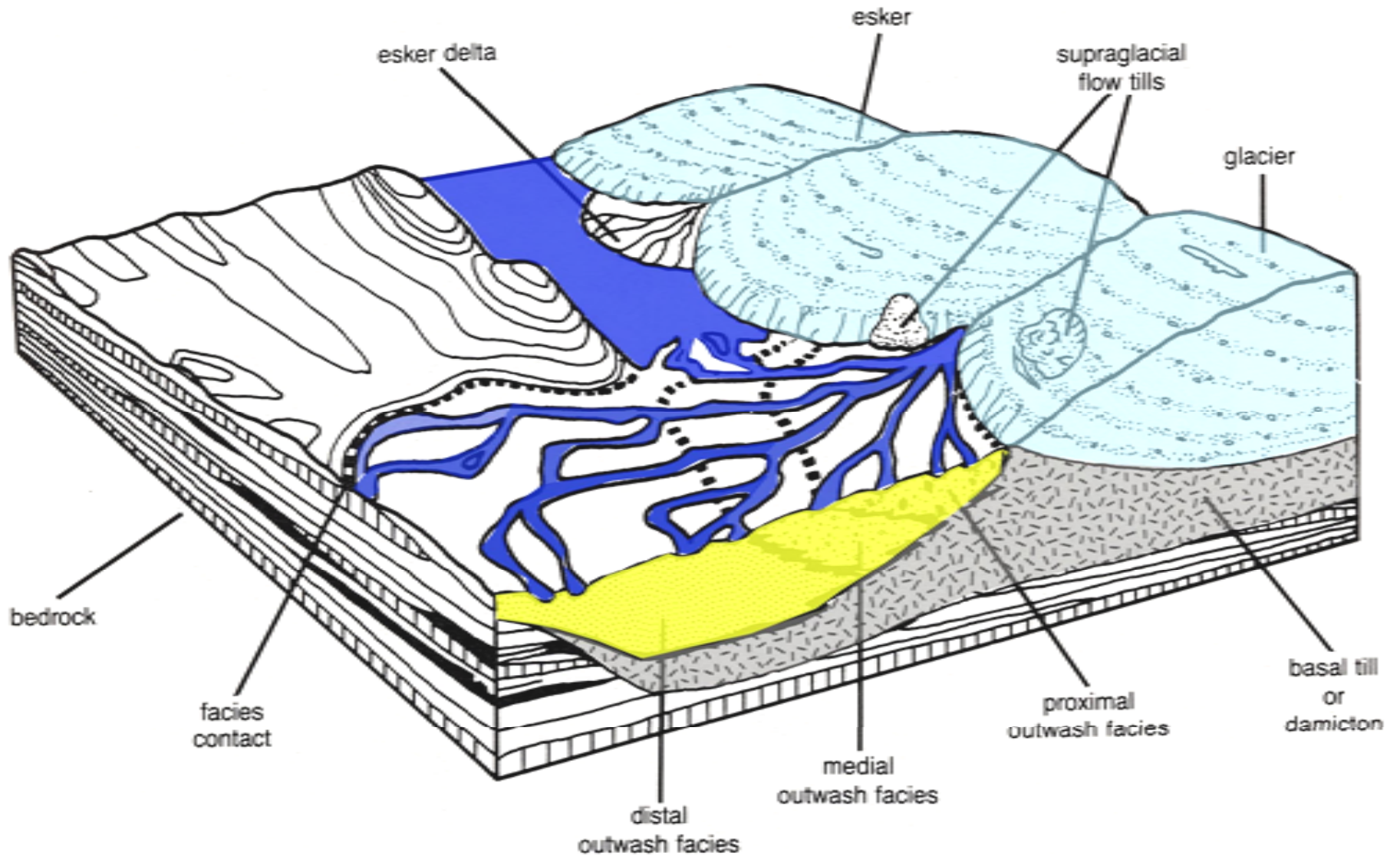
Illinois State
WATER
Resources



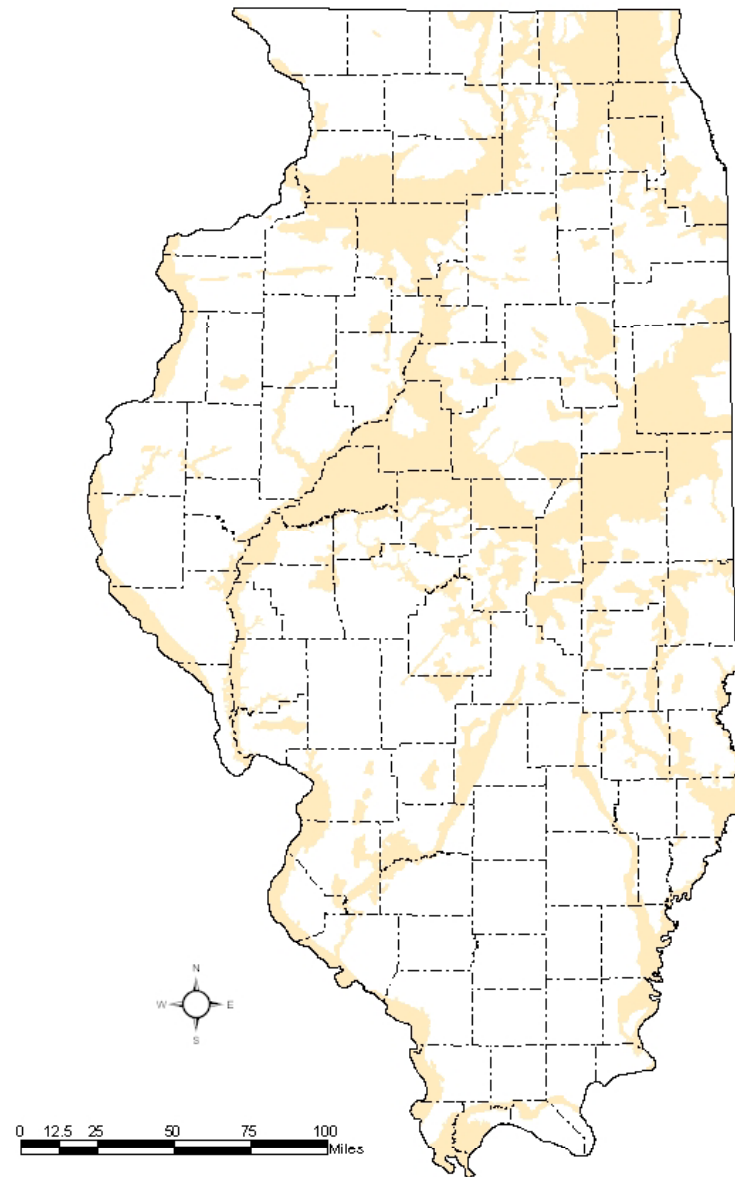
ILLINOIS



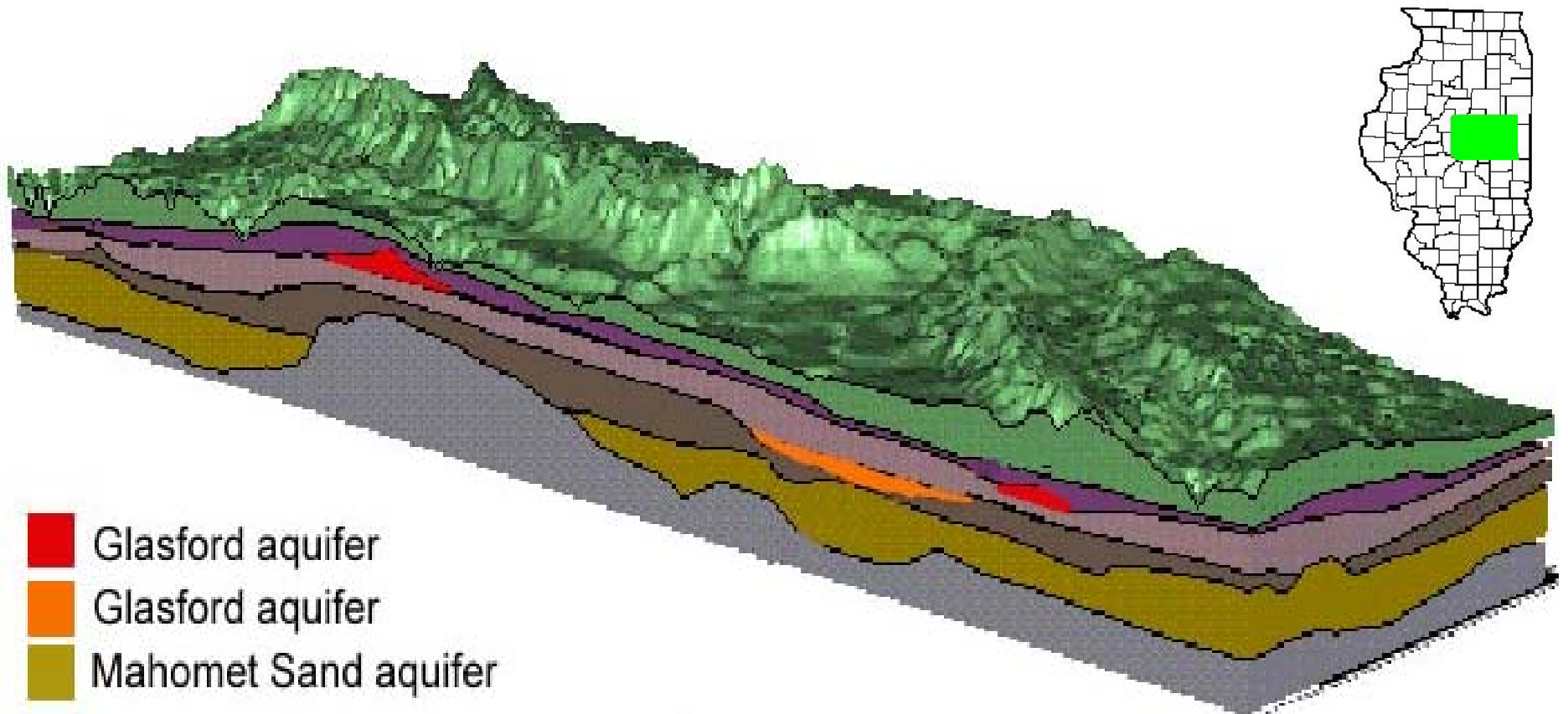
Glacial Depositional Processes



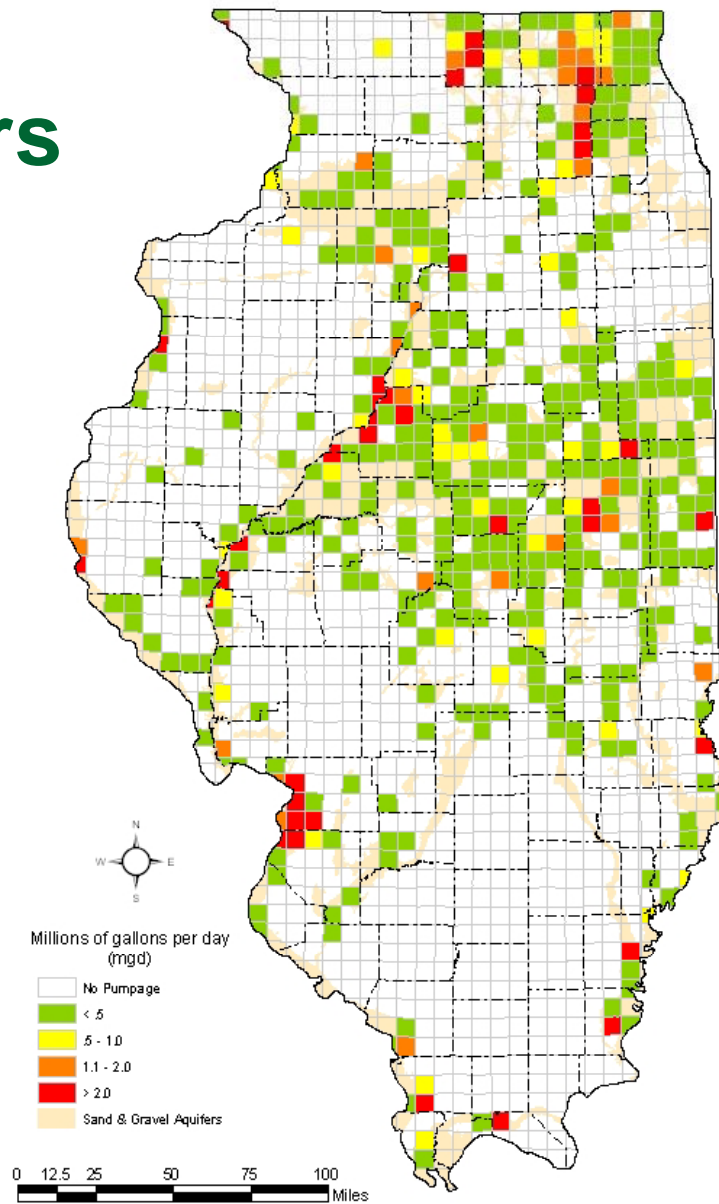
Major Sand & Gravel Aquifers



Geology of the Mahomet Aquifer



Withdrawals from Sand & Gravel Aquifers

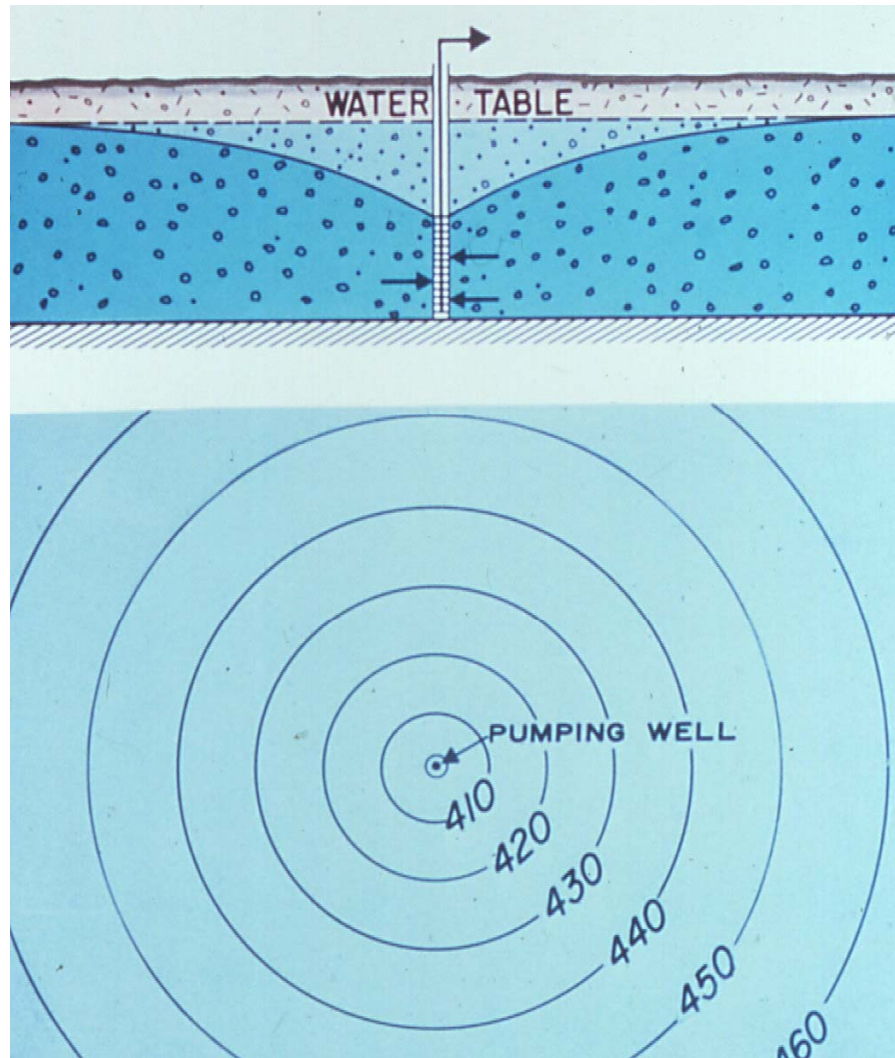


Total use ~ 400 mgd
+ ~200 mgd for irrigation

Regional Community Groundwater Use

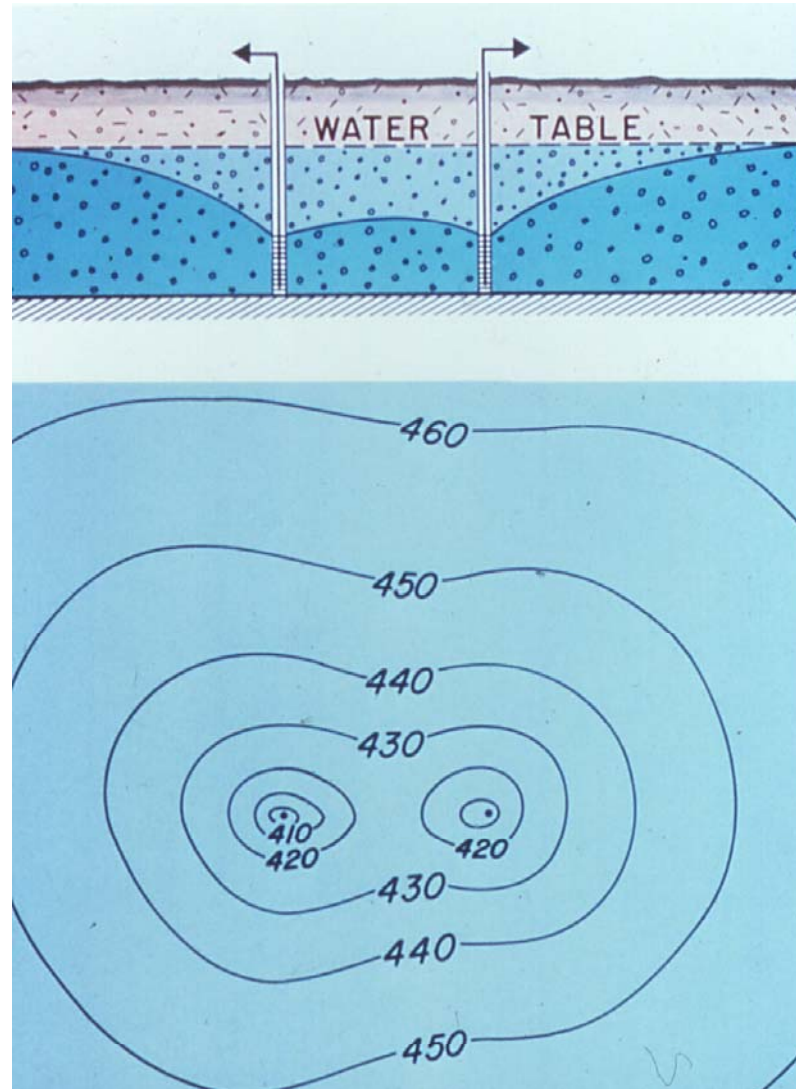
	<u>2004 Water Use (gpd)</u>
Gibson City (not Mahomet Aquifer)	730,000
IL-American Water Co.	21,000,000
Mahomet	500,000
Monticello	700,000
Normal	4,100,000
Paxton	650,000
Rantoul	1,600,000
Stone Ridge Dairy (near Bellflower)	~1,200,000
White Heath	50,000

Cone of Depression



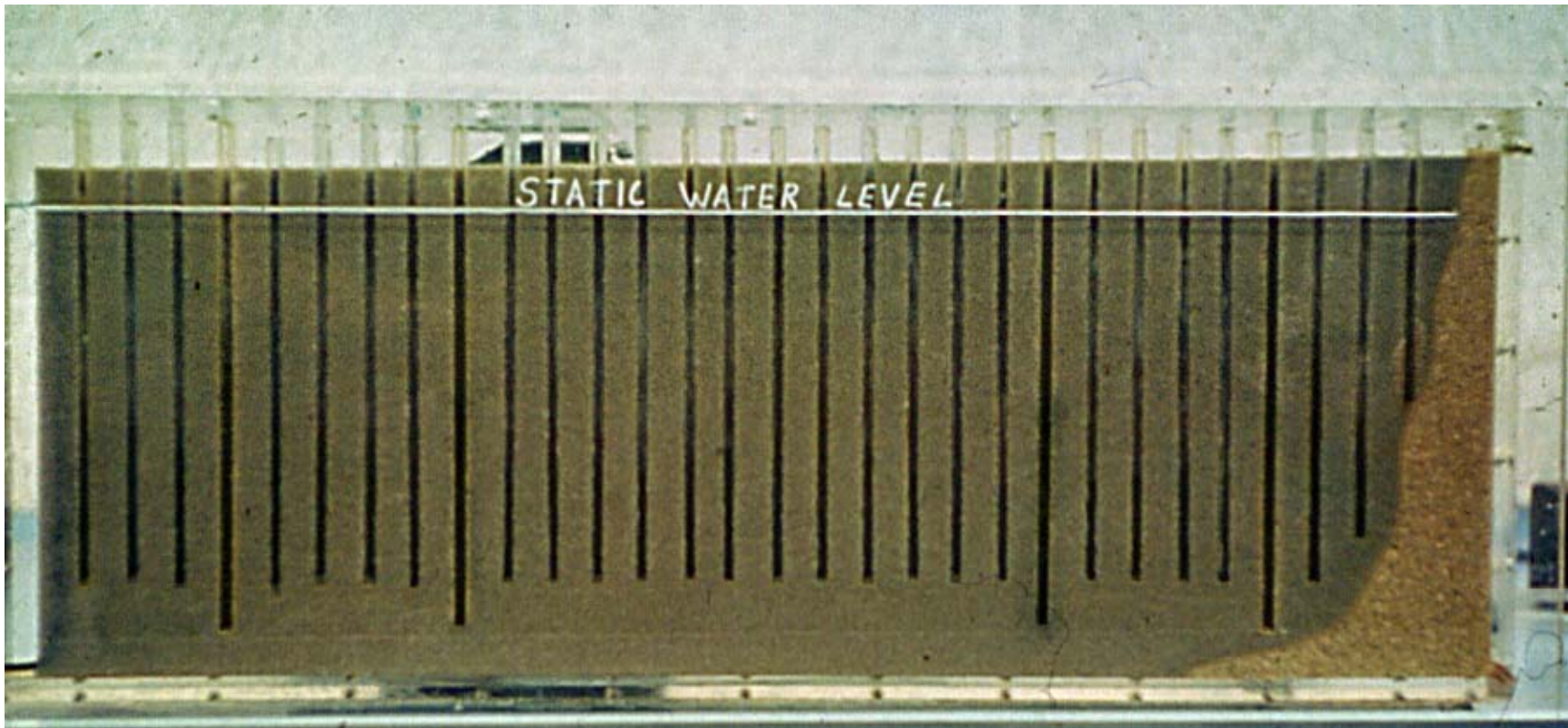
Well/Aquifer Interactions

Overlapping Cones of Depression



Well/Aquifer Interactions

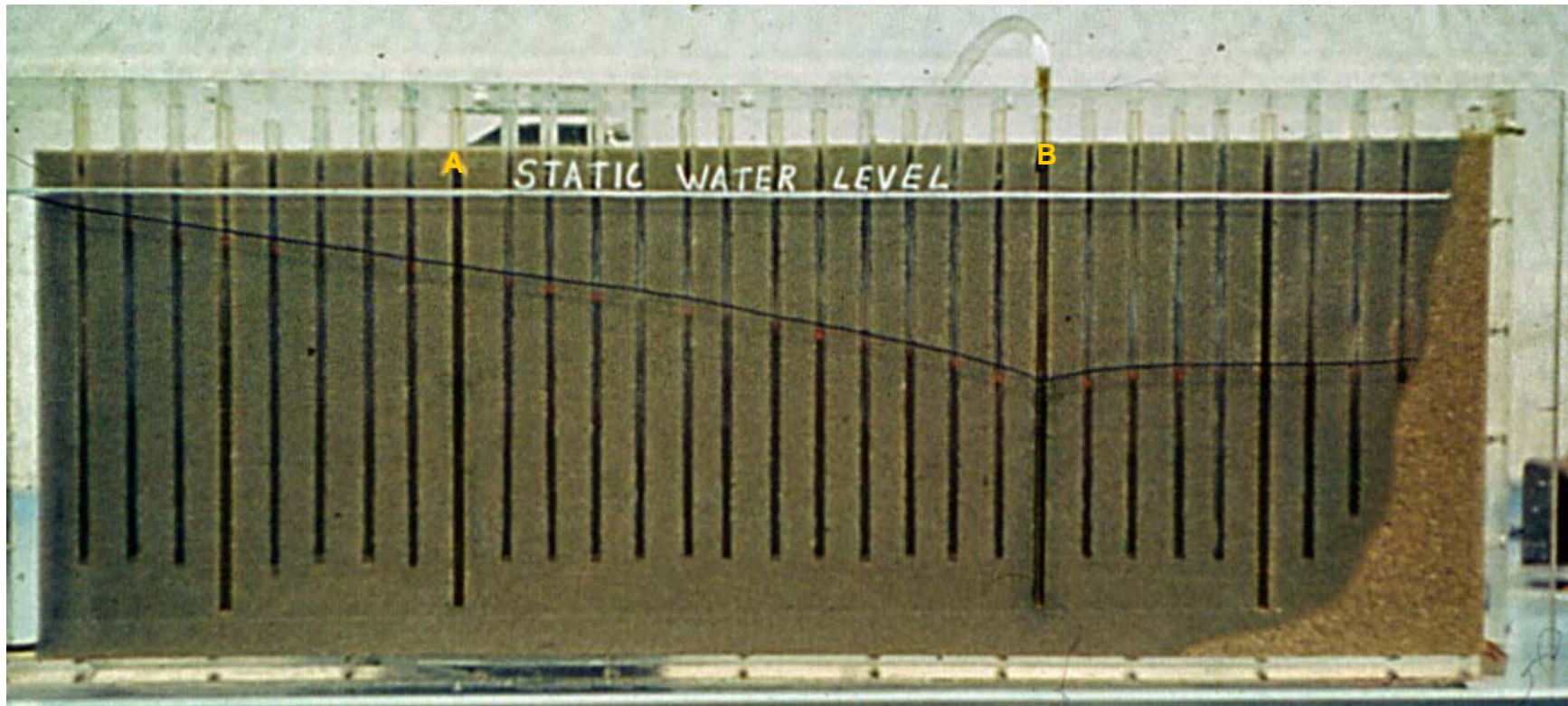
Overlapping Cones of Depression: Well Interference



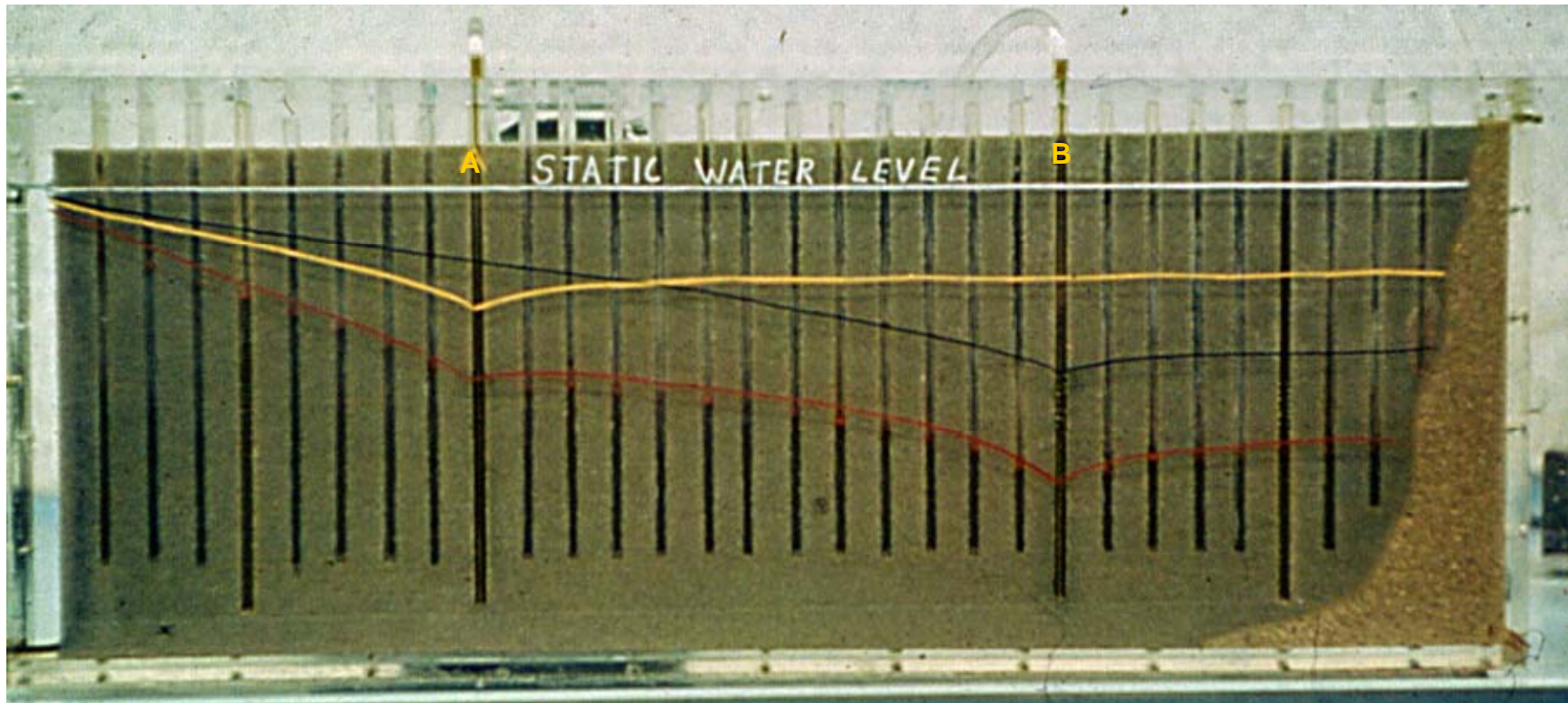
Overlapping Cones of Depression: Well Interference



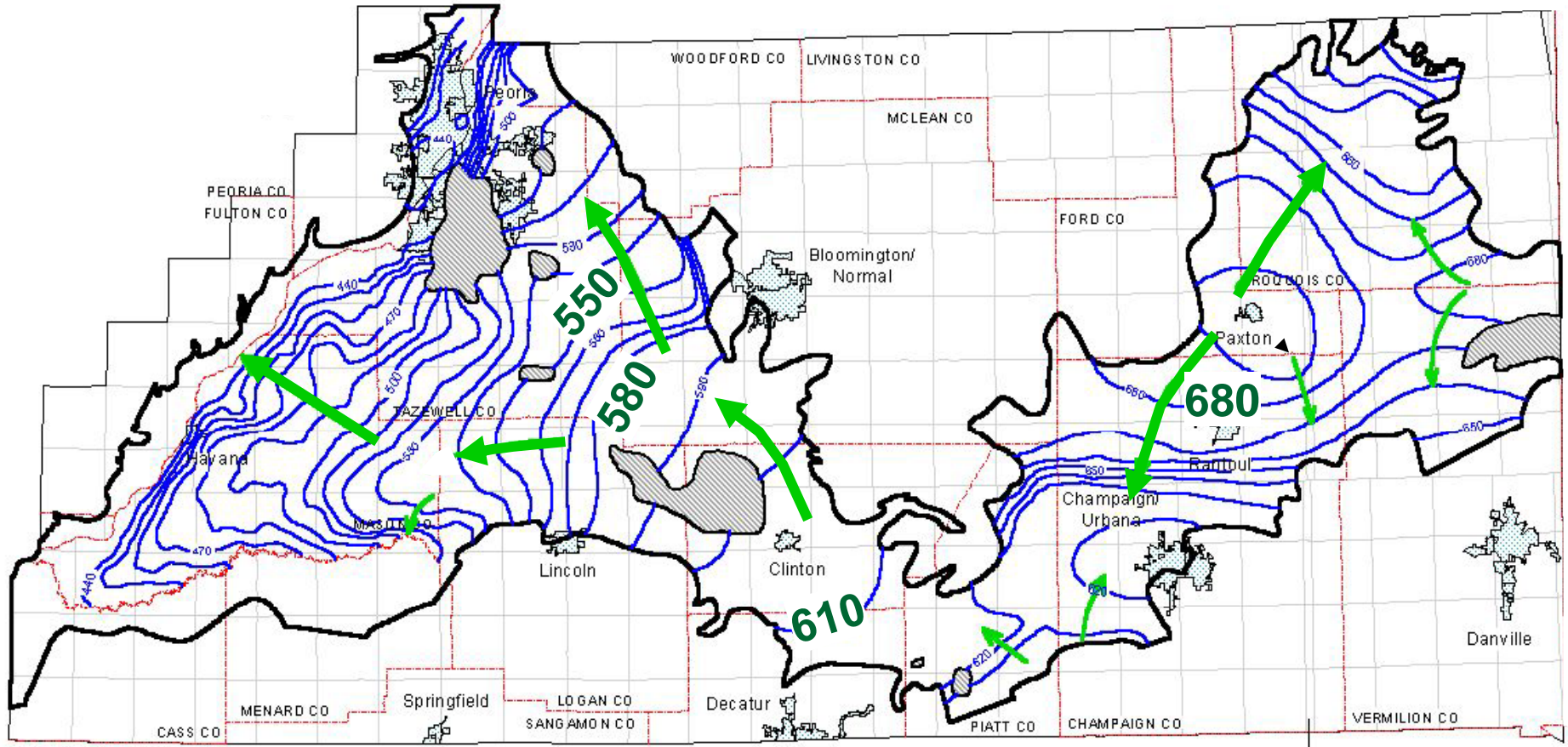
Overlapping Cones of Depression: Well Interference



Overlapping Cones of Depression: Well Interference

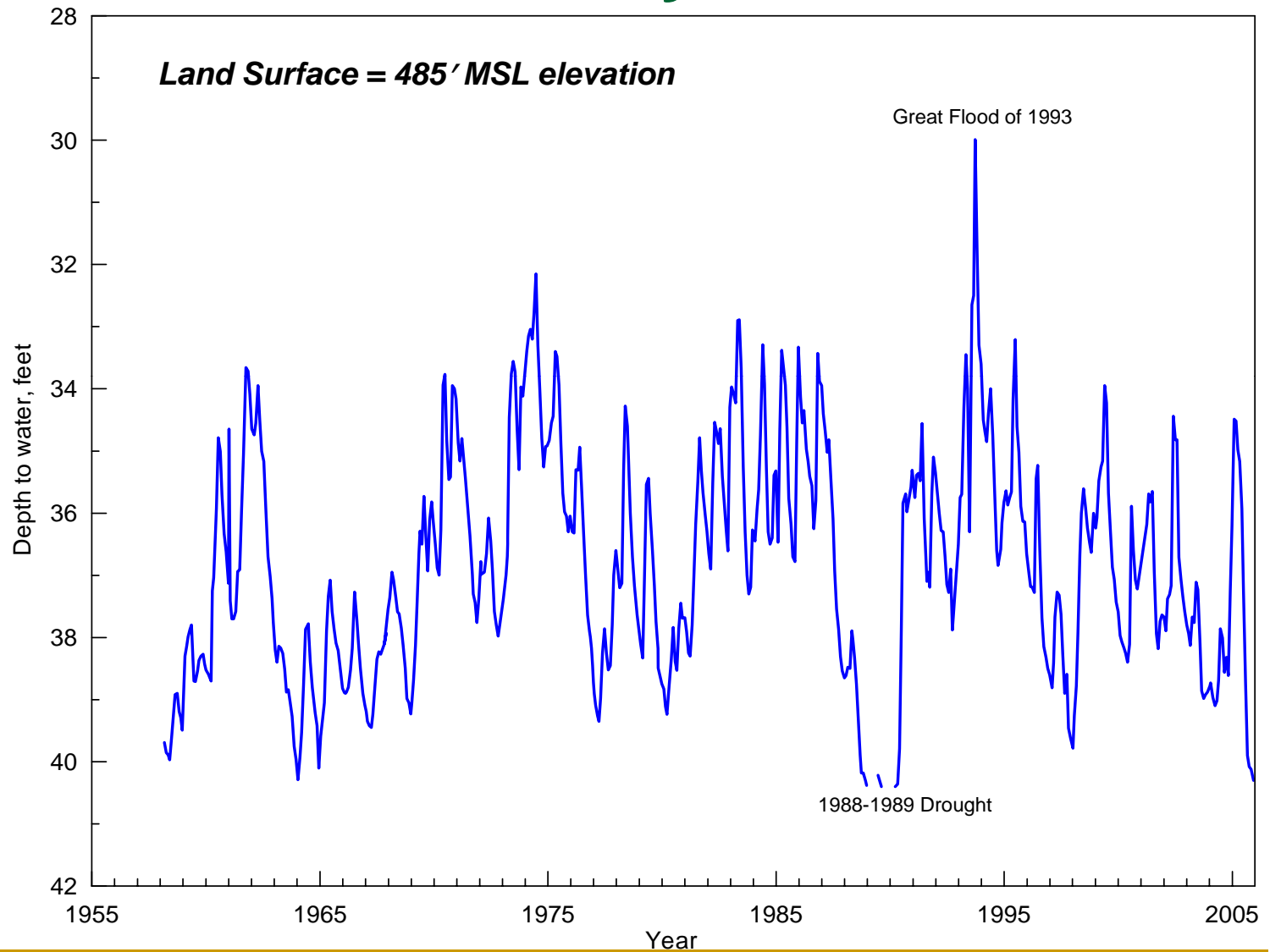


Mahomet Aquifer Groundwater Levels

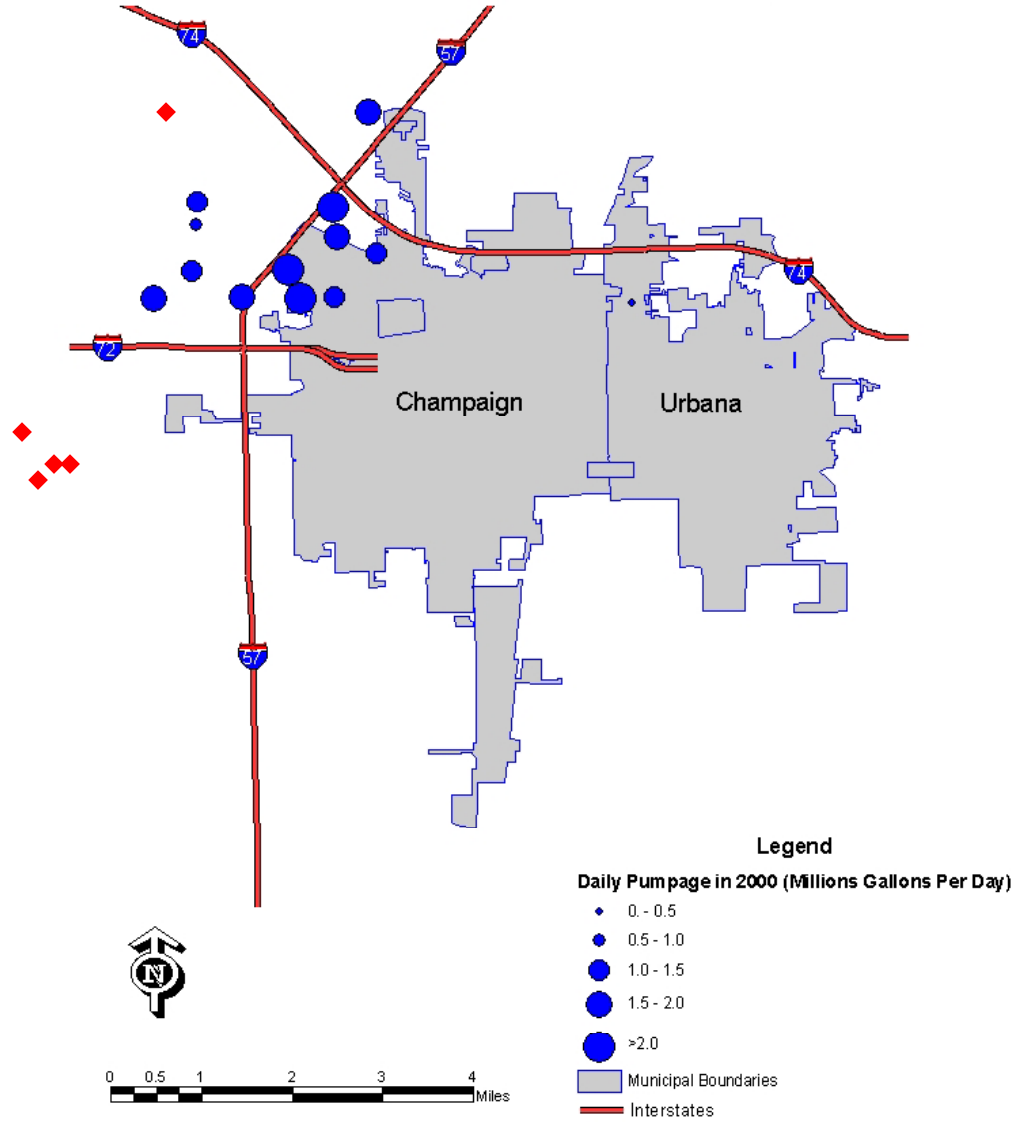


- 10-foot contour
- ← Flow direction

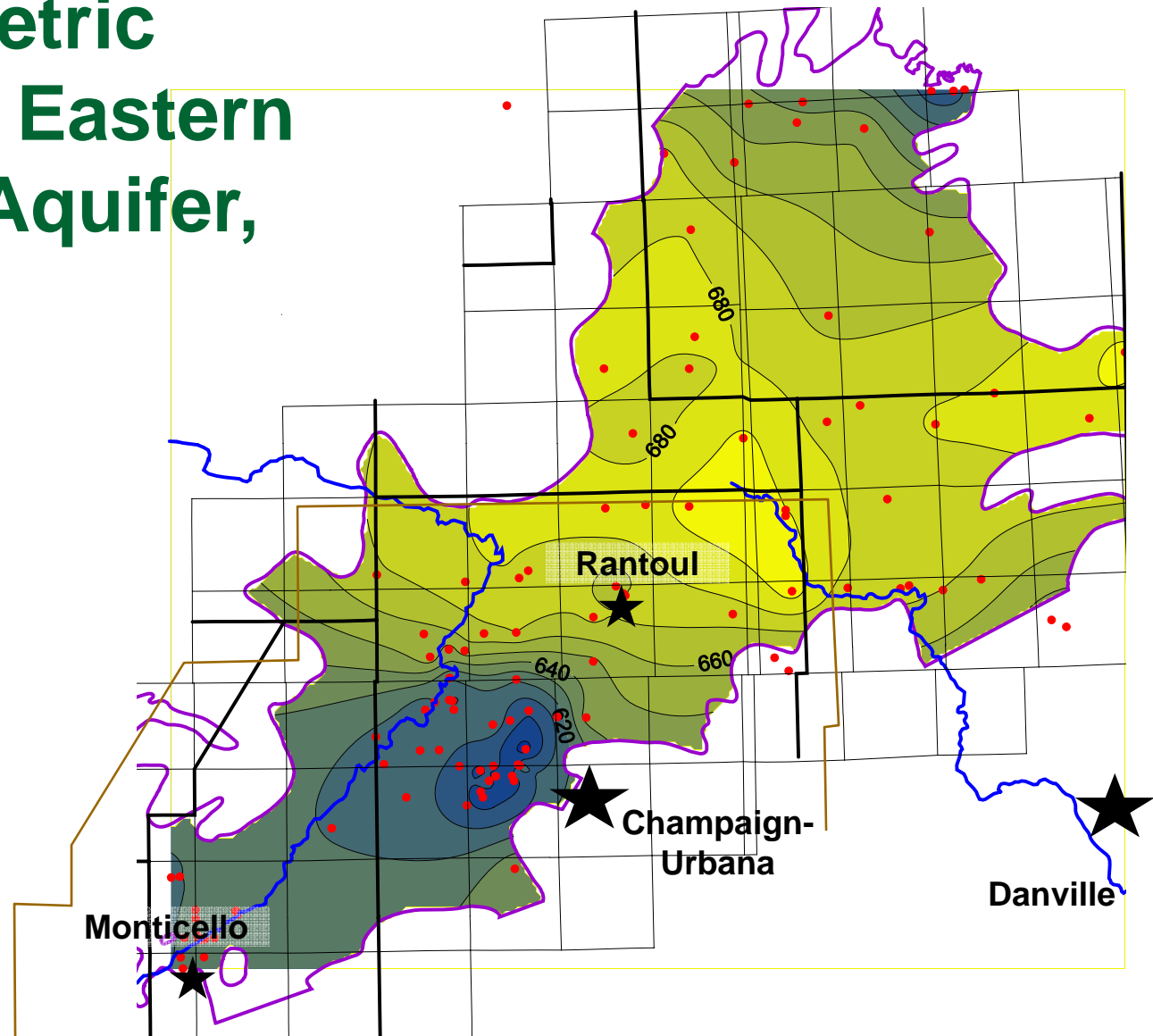
Mahomet Water Levels by the Illinois River



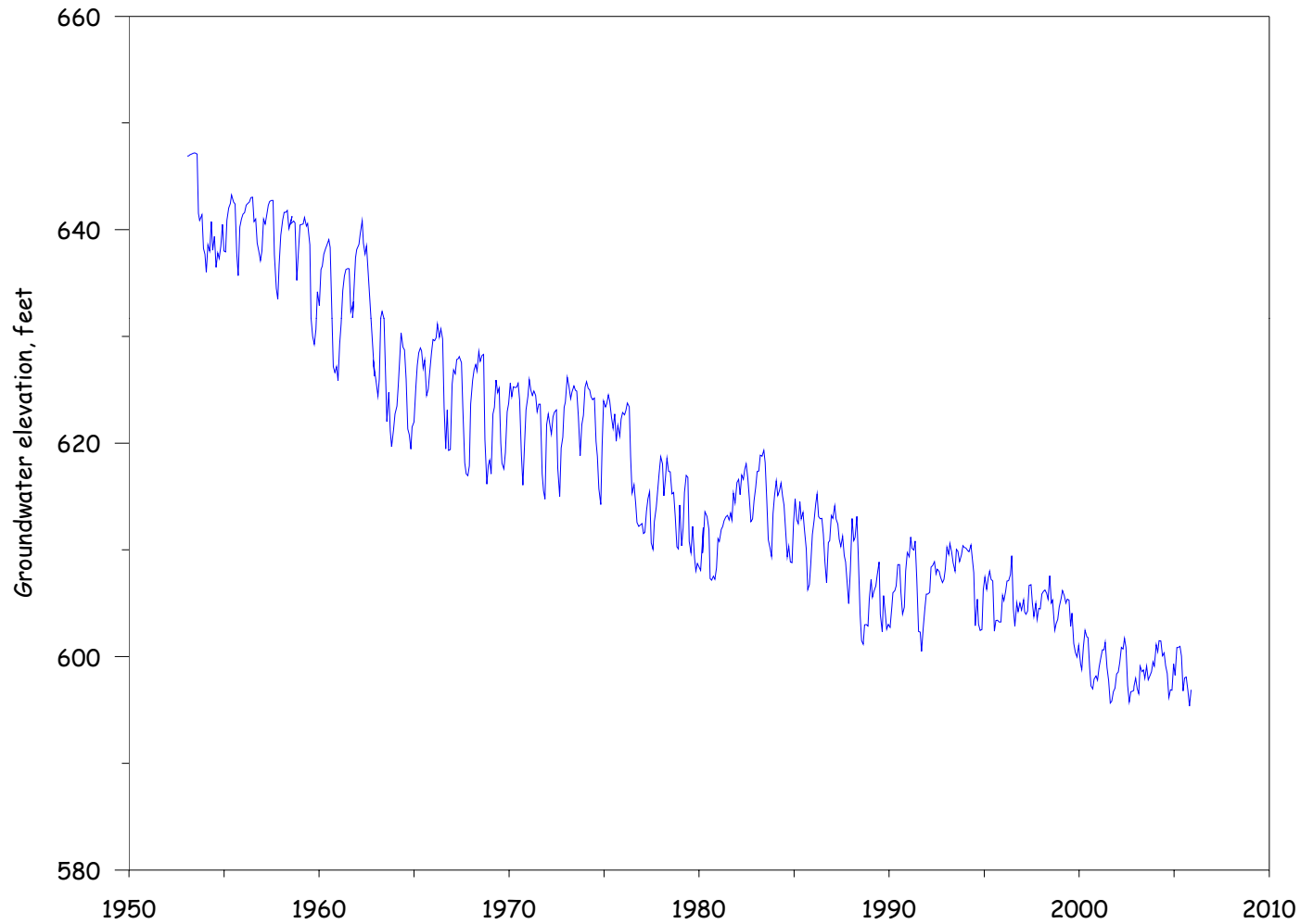
Top Producing Wells Owned by Illinois American Water Comany



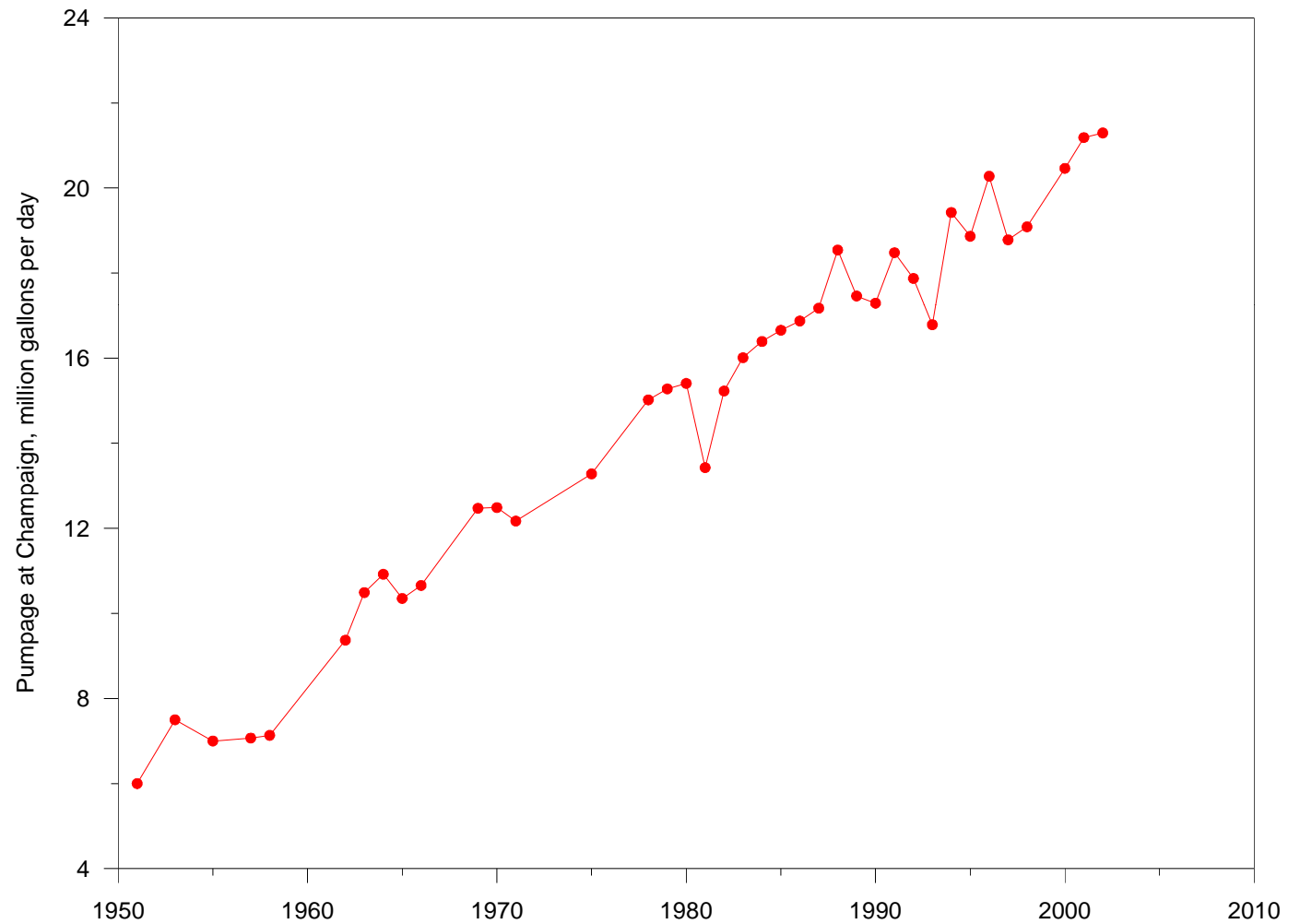
Potentiometric Surface of Eastern Mahomet Aquifer, 2005



Mahomet Potentiometric Heads near Champaign



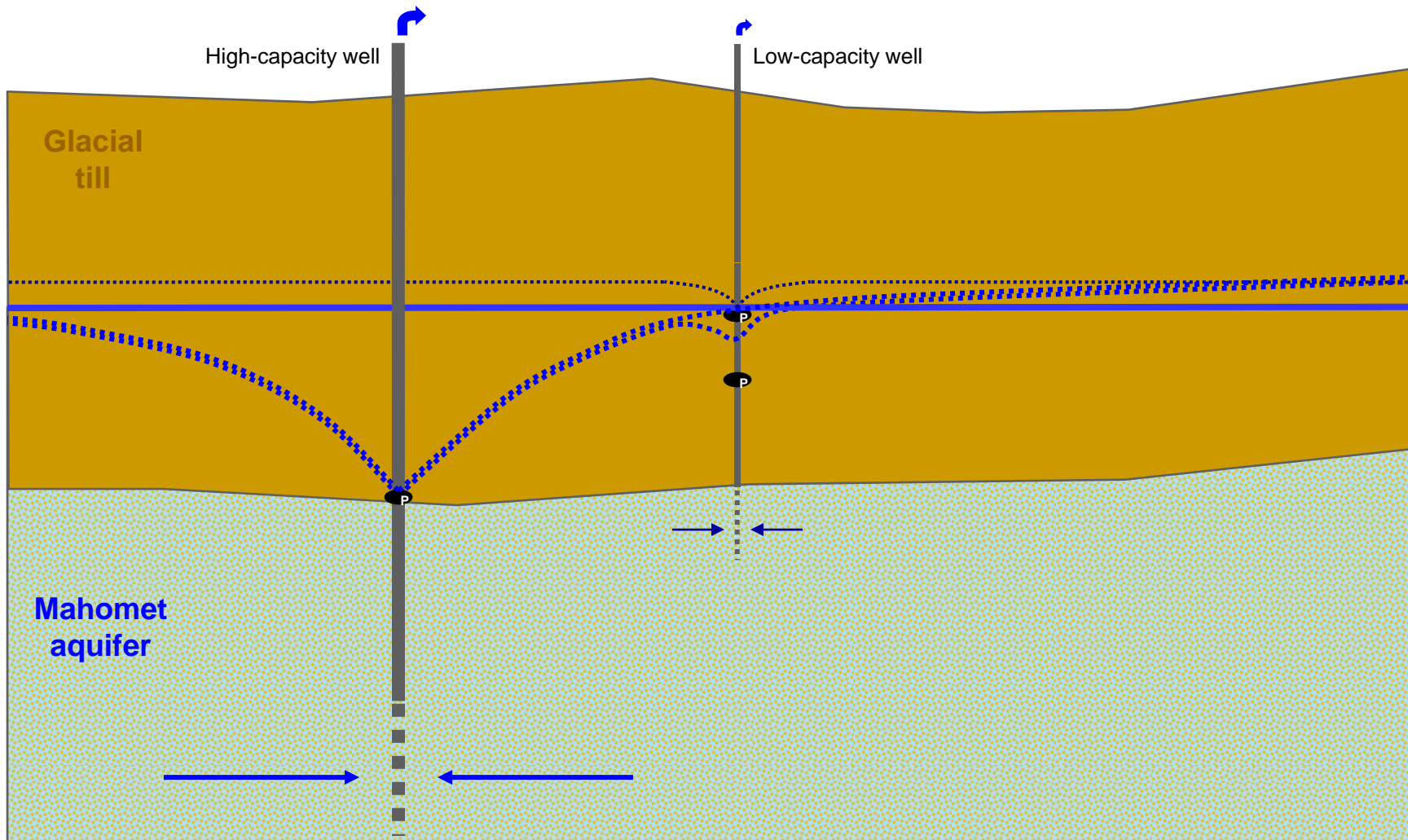
Water Use Trend at Champaign



Impacts of pumping on water levels (head)

— Mahomet aquifer pumping (artesian) head

● Pump settings



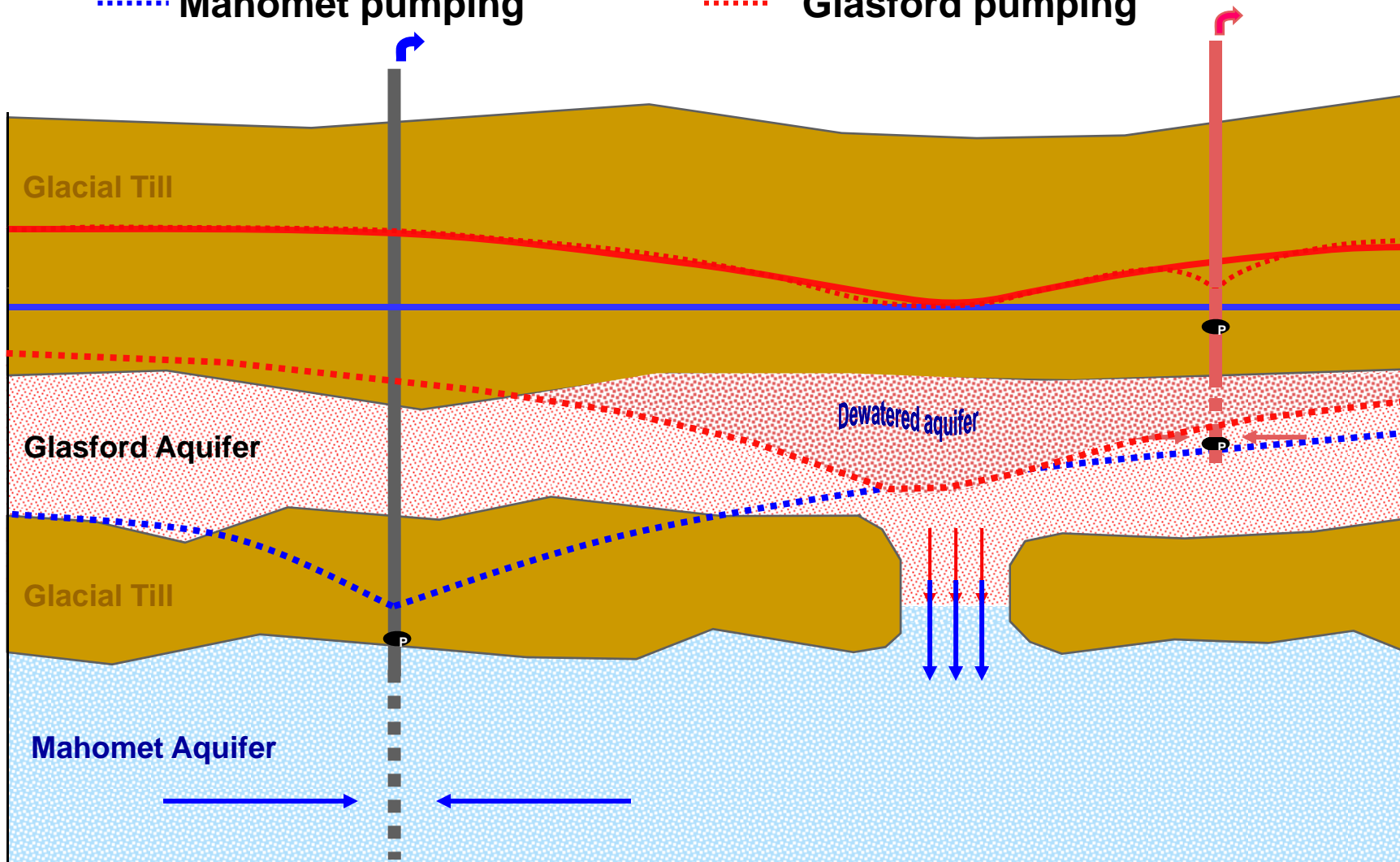
Impact of pumping hydraulically linked aquifers

— Mahomet nonpumping

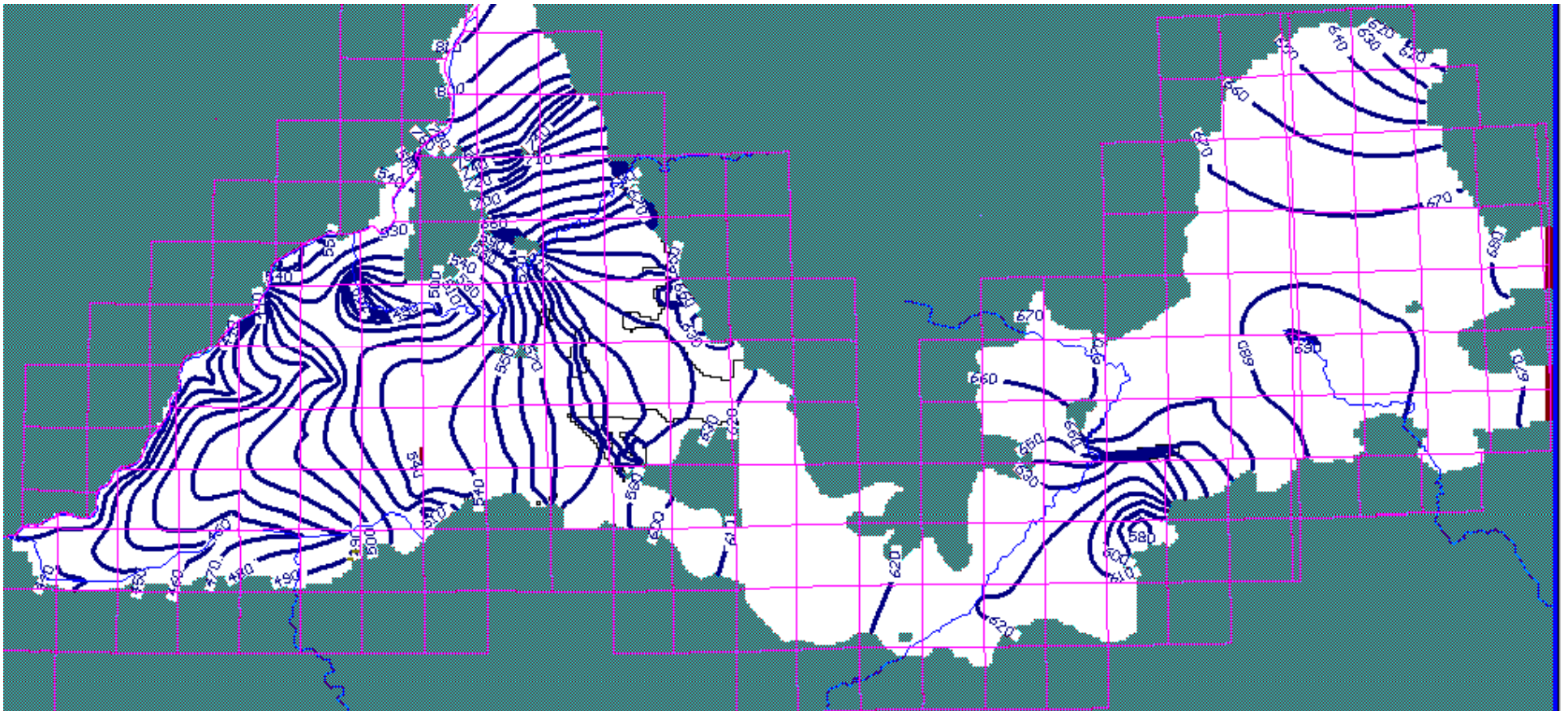
— Glasford nonpumping

⋯ Mahomet pumping

⋯ Glasford pumping

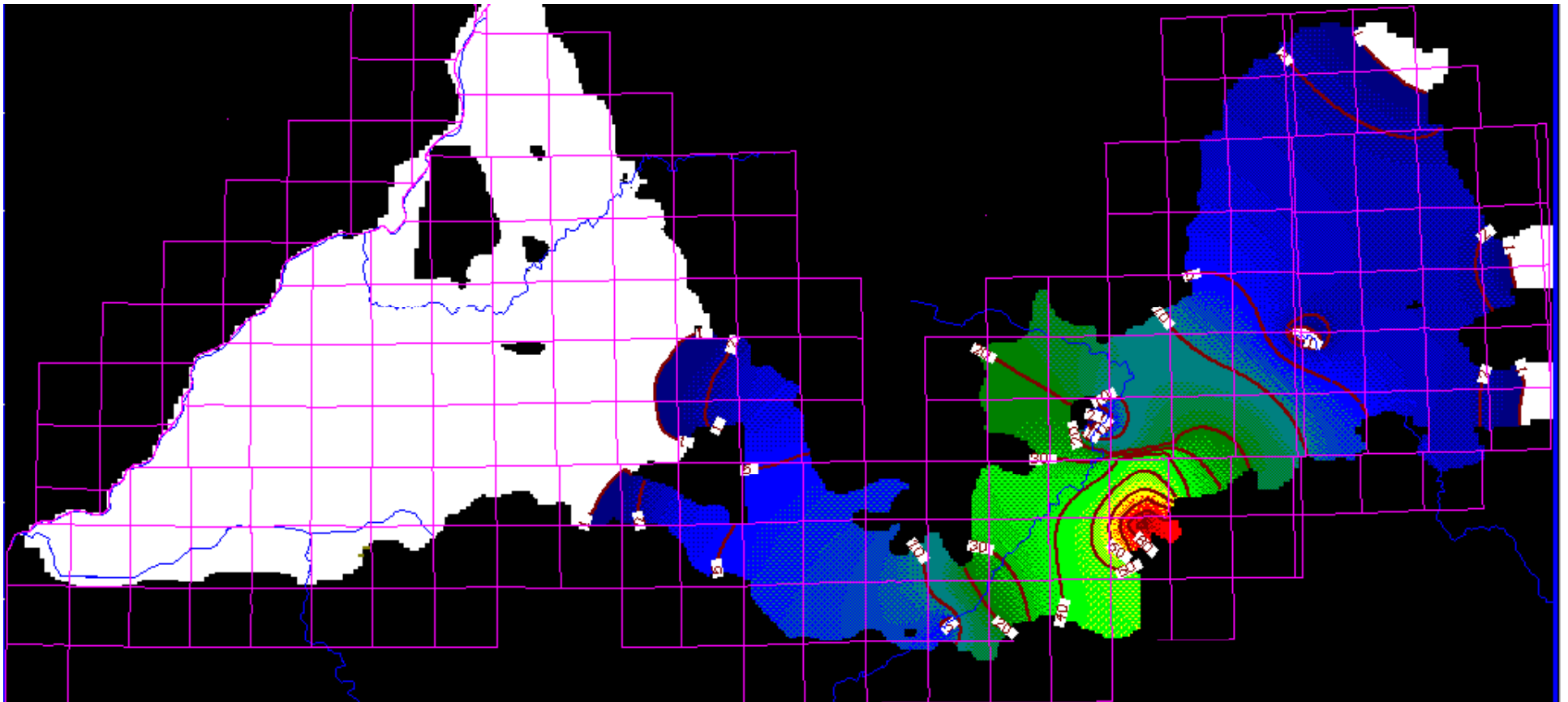


ISWS Regional Flow Model Predicted Heads



Model-Predicted Drawdown

$Q = 23 \text{ mgd at Champaign}$



Thanks!

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