Mapping – Planning for Community Groundwater Sustainability

Kurt O. Thomsen, Ph.D., P.G.
Principal
KOT Environmental Consulting, Inc.
Janet L. Agnoletti
Executive Director
Connie L. Pokorny
GIS Analyst
Barrington Area Council of Governments

The Problem

- **Available Groundwater Decreasing**
- **Water Quality Decreasing**
- **Expenses Increasing**
- **Good Management Practices Non-Existent**

The Problem (Continued)

"The Check Book Syndrome"

Withdrawal versus Recharge

Bank Savings

Deposit

Withdrawal

Savings = Deposits - Withdrawals

0 = Deposits - Withdrawals

The Problem (Continued)

- **Deep Rock Aquifers**
  - **Fairly Uniform Over Large Area**
  - **Large Volume of Water in Storage**
  - **Recharge Rate Very Low**
  - **Most Withdrawn Water Comes from Storage**
- **Deep Rock Aquifers Very Susceptible to Mining**

The Problem (Continued)

- **Shallow Unconsolidated Aquifer**
  - **Called a "Shallow Aquifer System"**
    - **Heterogeneity**
  - **Relatively Low Storage**
  - **Higher Recharge Rates**
  - **Amenable to Sustained Development**
  - **Susceptible to Contamination**

The Problem (Continued)

- **Management of Groundwater Resources**
  - **"The Straw Approach"**
  - **Good Management Above Ground**
  - **Poor Management Below Ground**
- **Underground Conditions Known and Ignored.**

The Problem (Continued)

- **Emphasis Shift from Deep Aquifers**
  - **Significant Drop in Water Levels**
  - **Decrease in Water Quality**
    - **Increases In:**
      - **Total Dissolved Solids**
      - **Sulfate**
      - **Chloride**
      - **Hardness**
      - **Arsenic**
      - **Radon**
      - **Radium**
      - **Gross Alpha**

The Problem (Continued)

- **Emphasis Shift to Shallow Aquifer System**
  - **Very Sensitive to Mismanagement**
    - **Over Pumping**
    - **Interference with Recharge**
    - **Susceptible to Contamination**

The Solution

Good Water Resource Management

Plan

Define

Protect

Plan

- **Needs Assessment – Current & Future Use**
  - **Domestic**
  - **Recreational**
  - **Commercial**
  - **Industrial**
- **Needs Assessment – Infrastructure**
  - **Wells/Well Fields**
  - **Distribution**
  - **Storage**
  - **Recharge**

Plan (Continued)

- **Needs Assessment – Policy**
  - **Economics**
  - **Zoning**
  - **Water Use**
  - **Water Law**

Define

Characterize Shallow Aquifer System

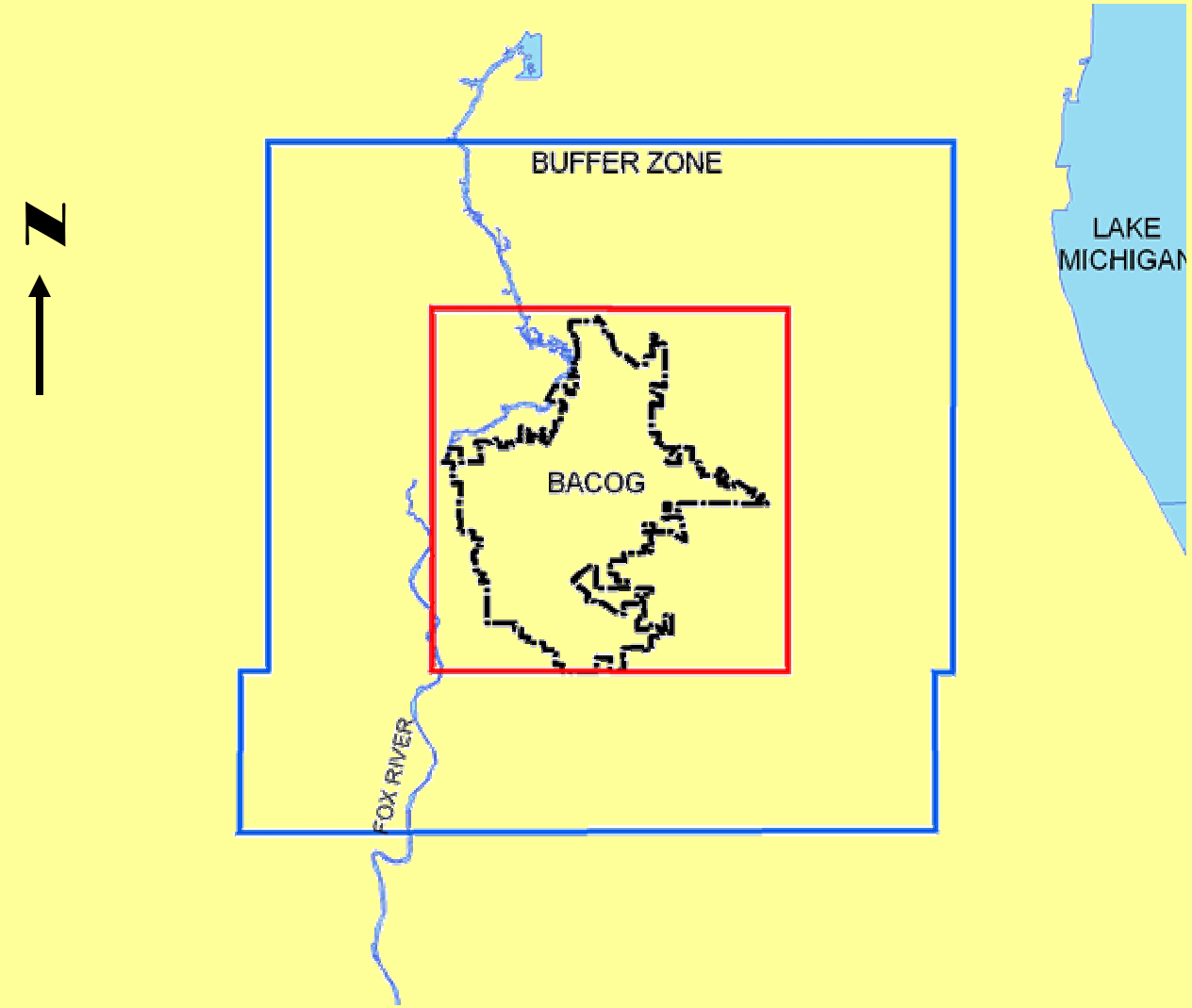
- Collect and Prepare Well Log Data
- Prepare Maps
  - Bedrock Surface
  - Basal Aquifer Thickness
  - Basal Aquifer Surface
  - Stack-Maps (Stratigraphy)
  - Recharge Areas

Define (Continued)

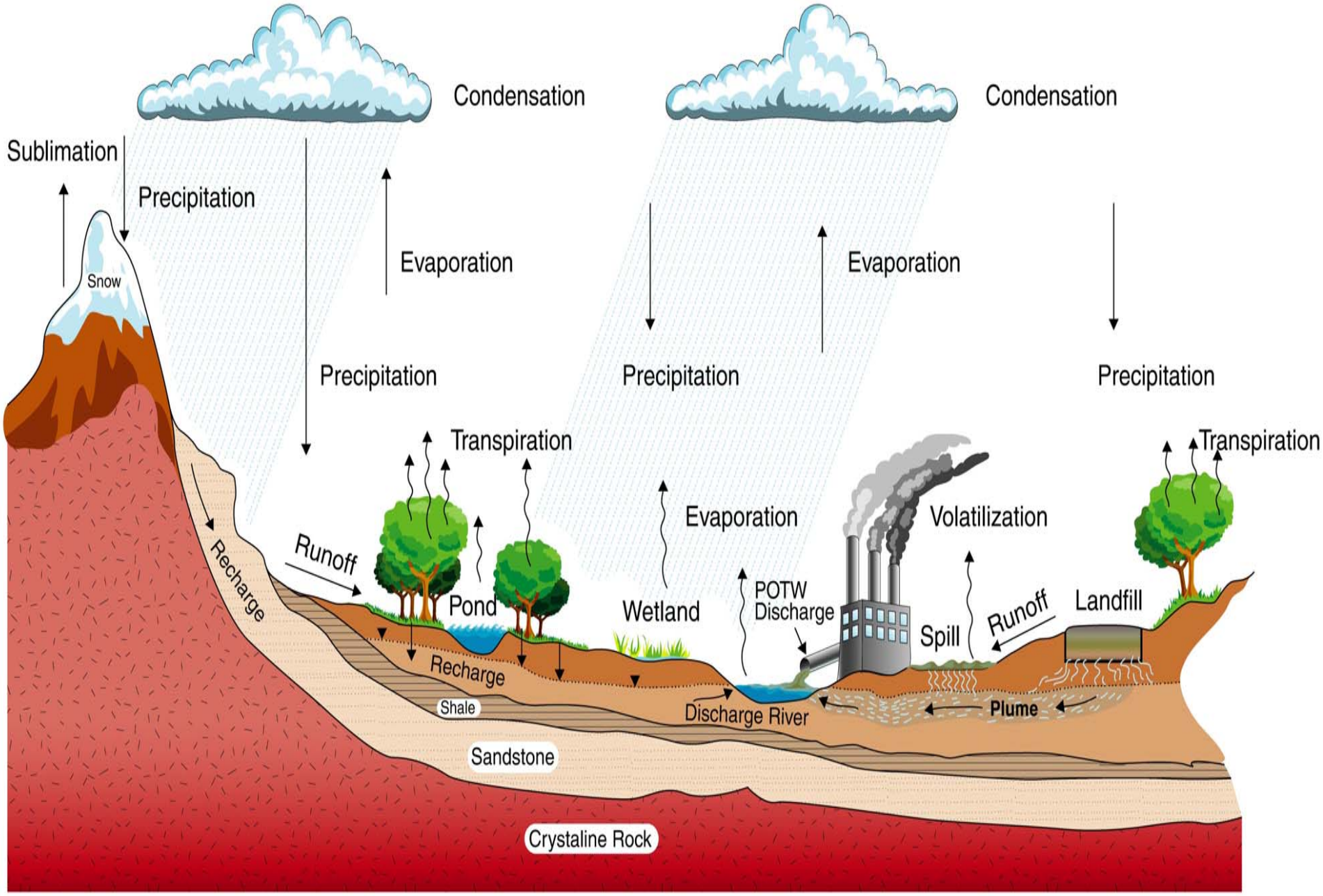
- **Estimate**
  - **Storage Capacity**
  - **Groundwater Seepage**
  - **Groundwater Through-Flow**
  - **Discharge**
  - **Recharge**
  - **Consumption**
  - **Septic Loading**

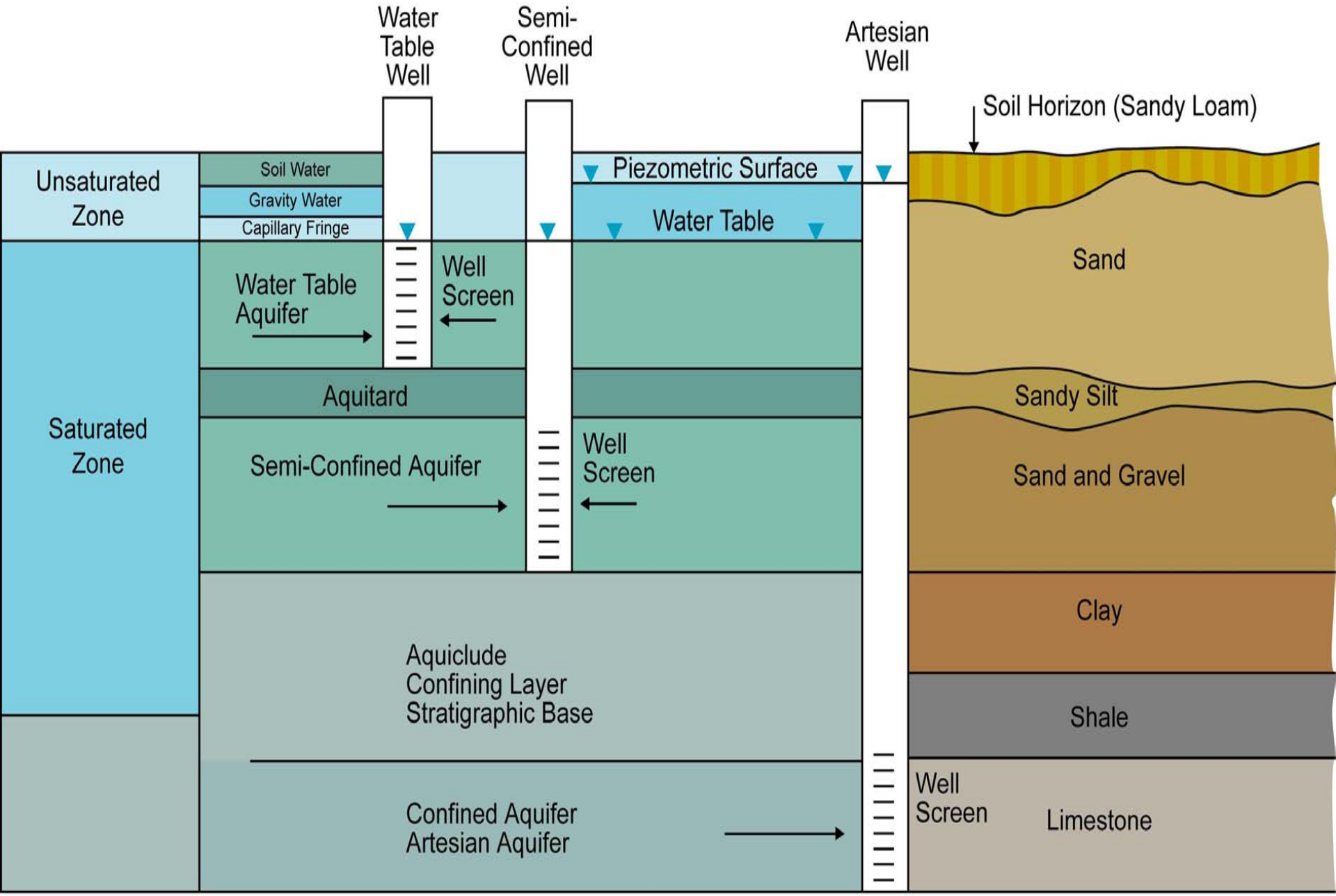
Protect

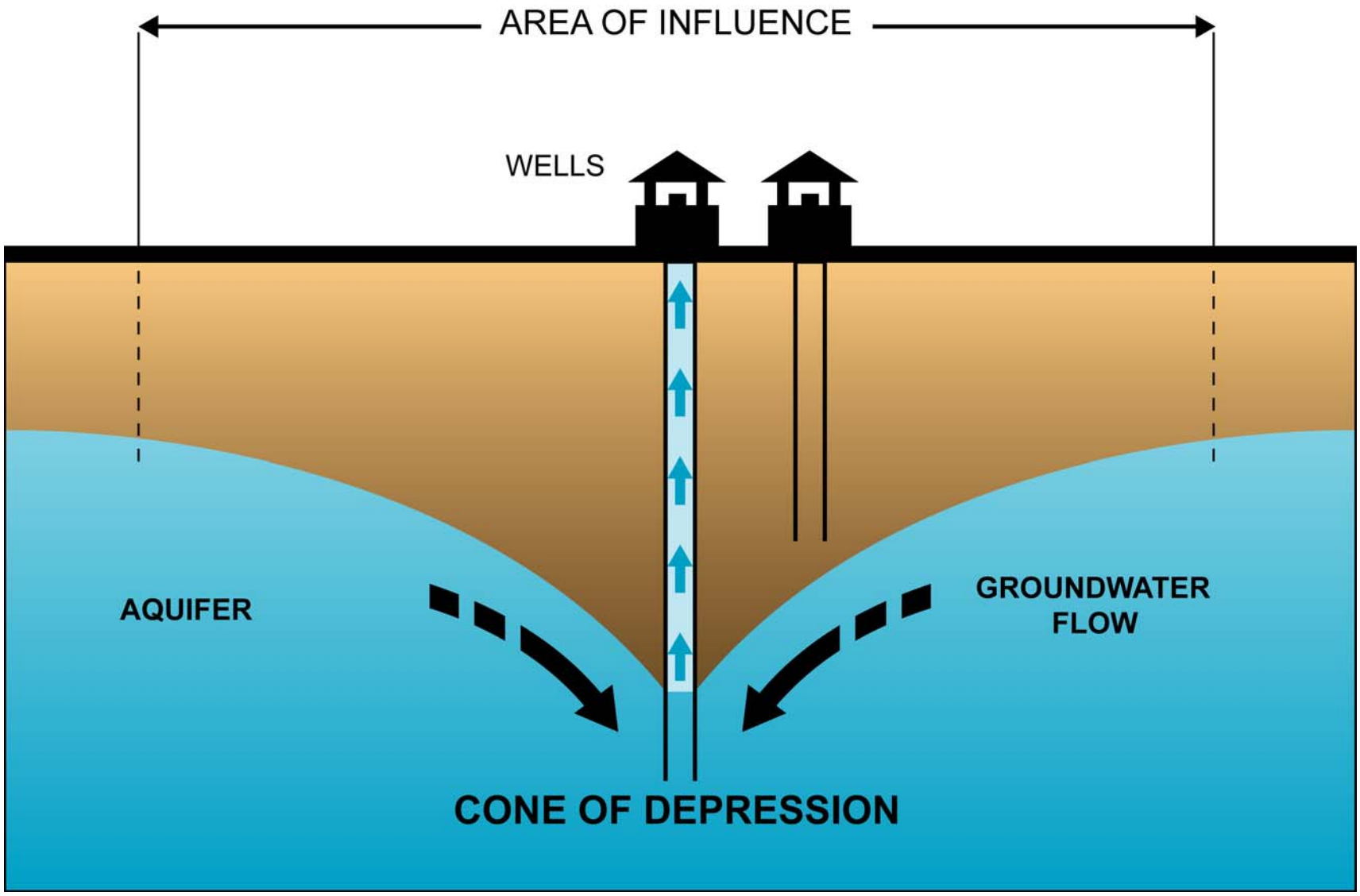
- **Maintain and Expand Green Spaces**
  - **Wetlands**
  - **Forests**
  - **Greenways**
  - **Open Lands**
- **Maintain and Expand Recharge Areas**
  - **No Development in Recharge Areas**
  - **Run-off to Recharge**
  - **Well Head Protection**



Water Resource Initiative Study Area


Condensation
Condensation
Sublimation
Precipitation
Evaporation
Evaporation
Snow
Precipitation
Precipitation
Precipitation
Transpiration
Transpiration
Evaporation
Volatilization
Runoff
Recharge
Pond
Wetland
POTW
Discharge
Spill
Runoff
Landfill
Recharge
Shale
Discharge River
Plume
Sandstone
Crystaline Rock

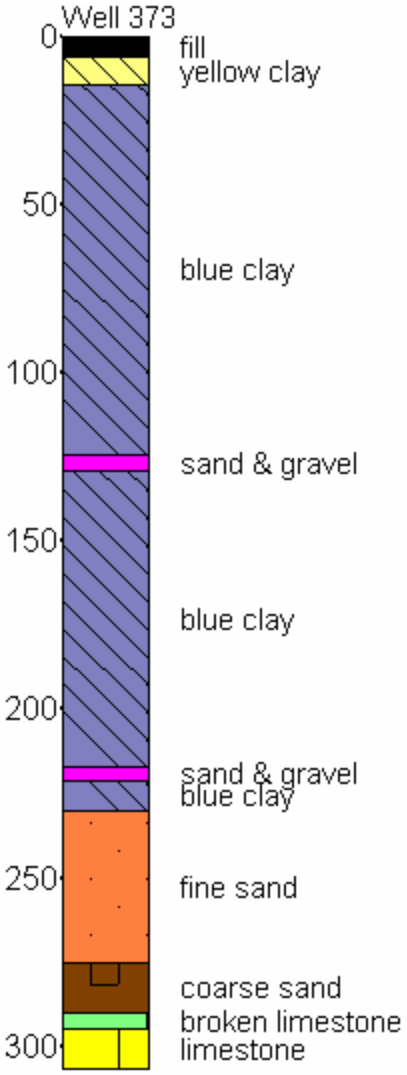

Water Table Well
Semi-Confined Well
Artesian Well
Soil Horizon (Sandy Loam)
Unsaturated Zone
Soil Water
Gravity Water
Capillary Fringe
Piezometric Surface
Water Table
Saturated Zone
Water Table Aquifer
Well Screen
Aquitard
Semi-Confined Aquifer
Well Screen
Aquiclude Confining Layer Stratigraphic Base
Confined Aquifer Artesian Aquifer
Well Screen
Sand
Sandy Silt
Sand and Gravel
Clay
Shale
Limestone


AREA OF INFLUENCE
WELLS
AQUIFER
GROUNDWATER
FLOW
CONE OF DEPRESSION

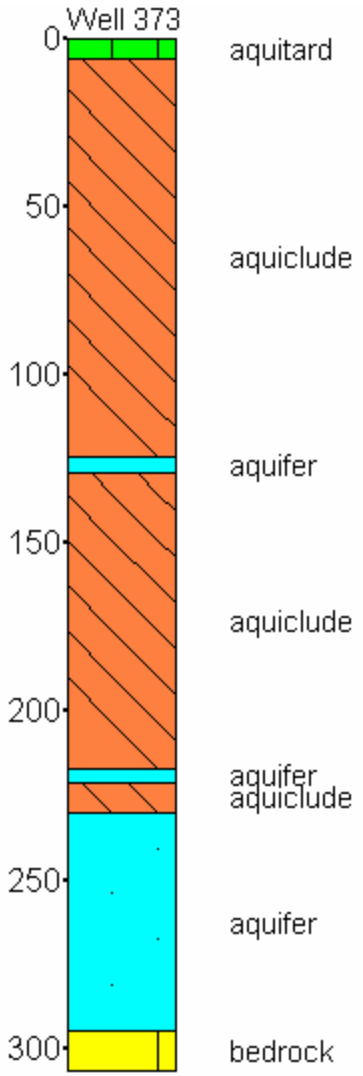
Data Preparation

- **Well Log Descriptions**
  - **Convert to Hydraulic Conductivity Values**
- **Establish Hydrogeologic Units**
  - **Aquifer**
  - **Aquitard**
  - **Aquiclude**

Stratigraphy



Hydrogeologic Units



Typical Study Area Well

Method Components

- **Query**
- **Populate**
- **Use**

QUERY

- **Setup Classification for Standard Descriptions**
- **Preview Database for Unique Attributes**
- **Run Summary Tables Periodically**
- **Eliminate Adjectives**
  - **Colors, Fine, Coarse, Light, Dark, etc.**
- **Final Summary Table Lists All Possible Standard Descriptions**

QUERY (Continued)

- **Sand and Gravel** **Gravel and Sand**
- **Sand, Gravel** **Gravel, Sand**
- **Sand & Gravel** **Gravel & Sand**
- **Sand/Gravel** **Gravel/Sand**
- **Sand-Gravel** **Gravel-Sand**

All Become Sand and Gravel

Querying Statistics

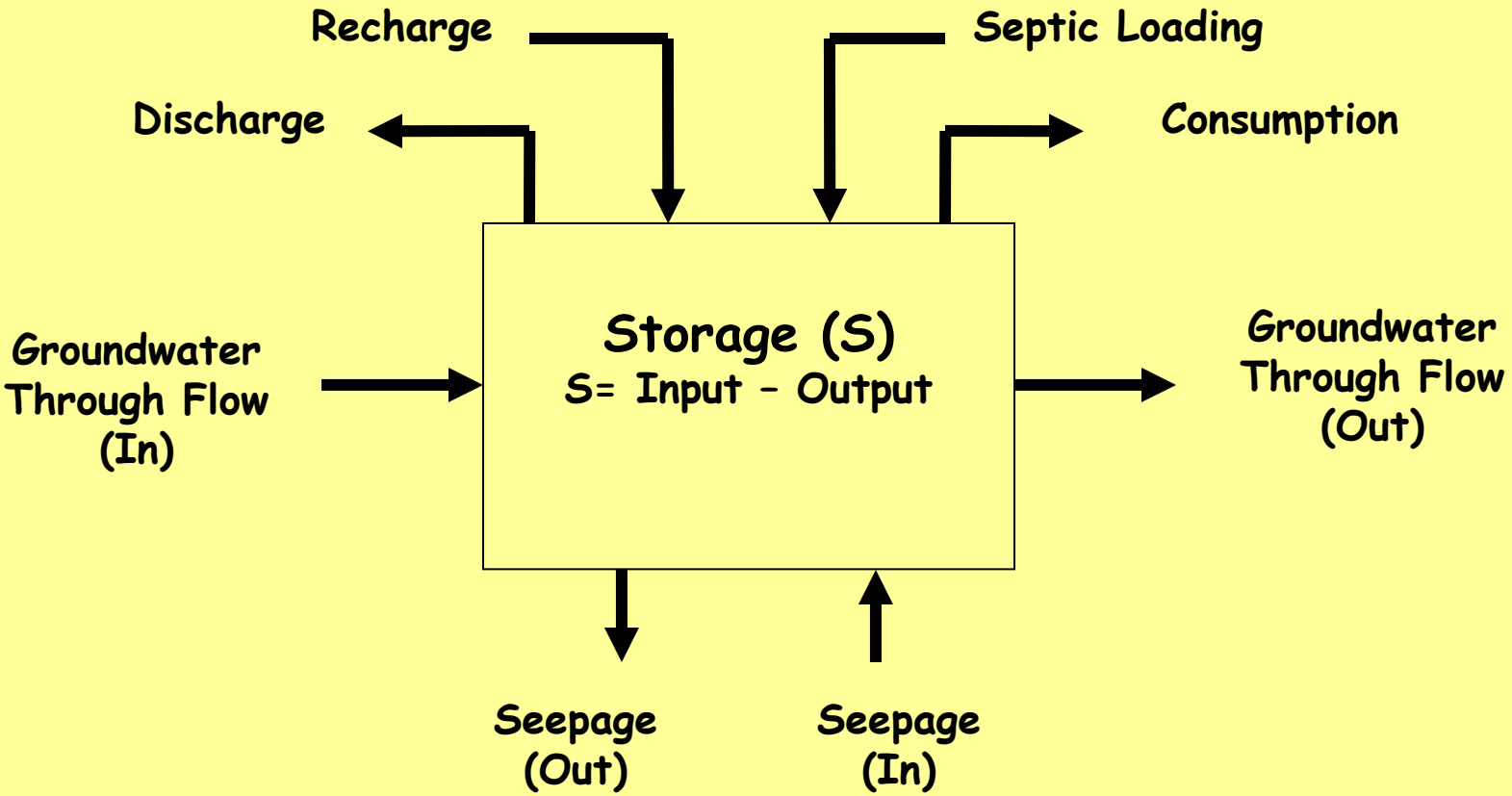
- **106,000 Lines of Data**
- **Time to Query Database: ~700 to 750 Hours**
- **Started with ~15,000 Unique Identifiers**
- **Ended with ~ 750 Unique Identifiers**
- **1000 Miscellaneous Lines**
- **Time to Prepare to Populate Database: 75 Hours**
- **Time to Populate Database: ~80 to 120 Hours**

Populate

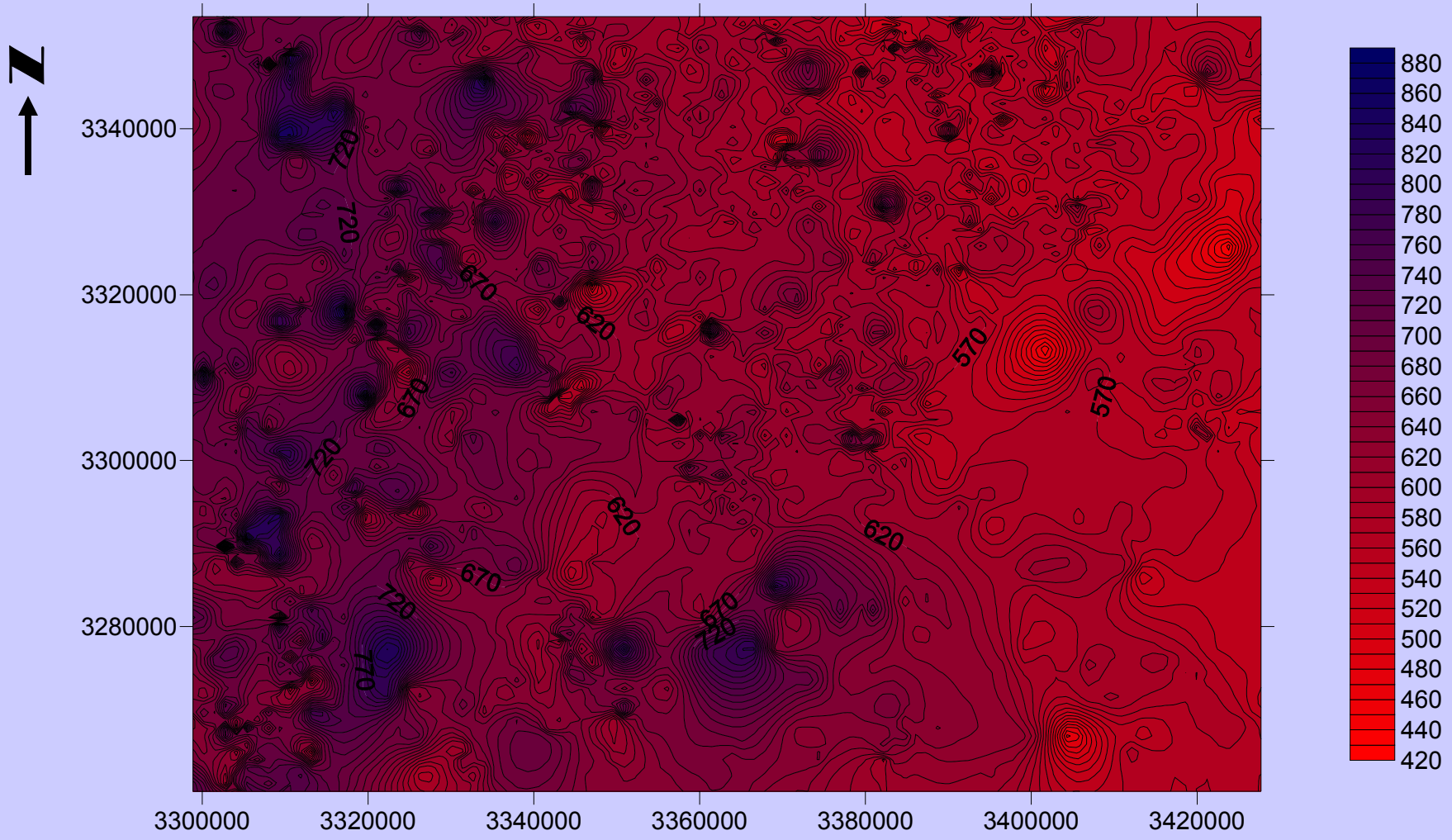
- **Soil Hydraulic Conductivity**
- **Interpretation and Conversion**
- **Hydrogeologic Units**

USE

- **Software:**
  - **Access**
  - **Spatial Analyst**
  - **3D Analyst**
  - **Surfer 8**
  - **RockWorks 2004**

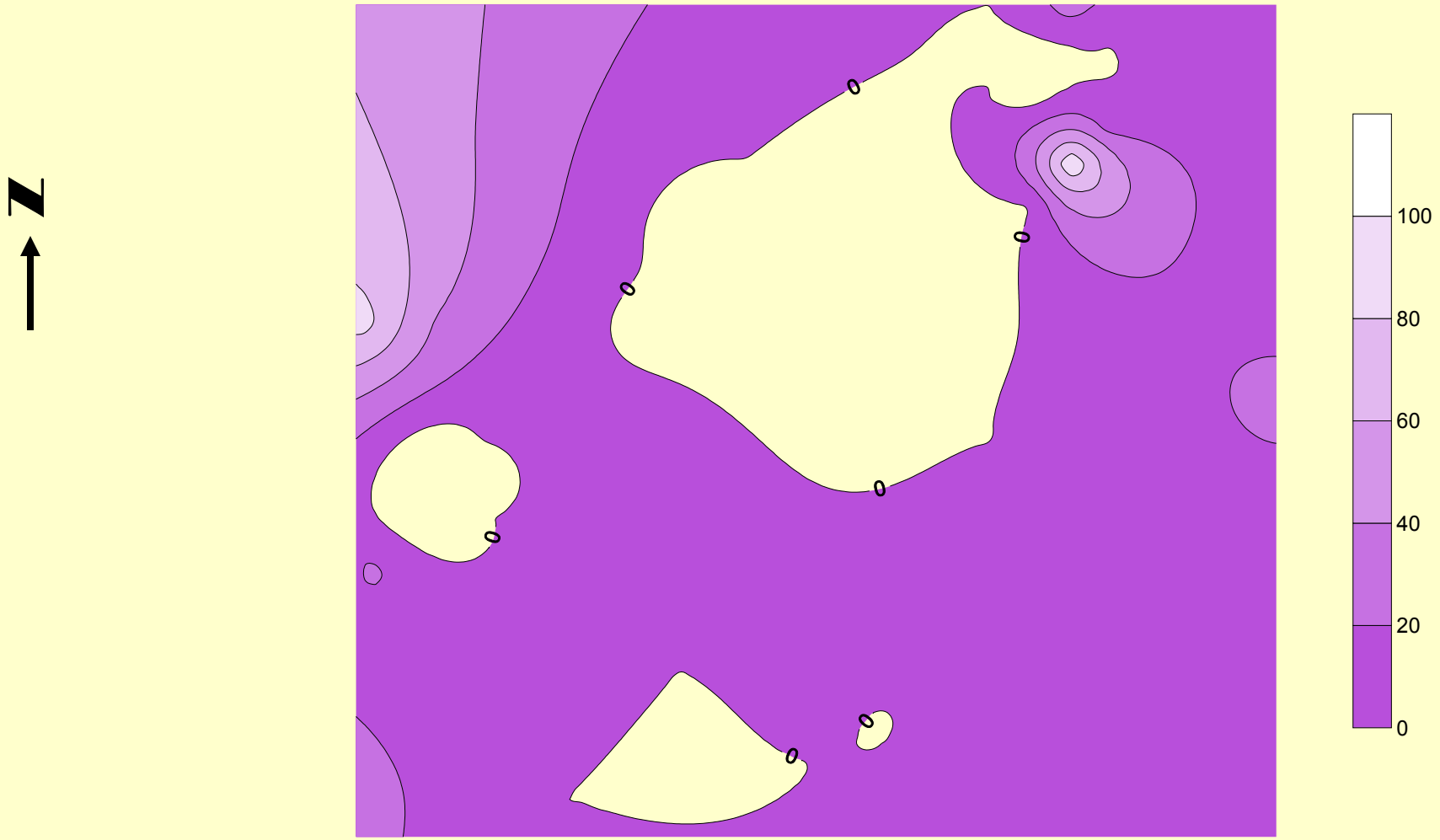


Conceptual Water Budget for the Shallow Aquifer System



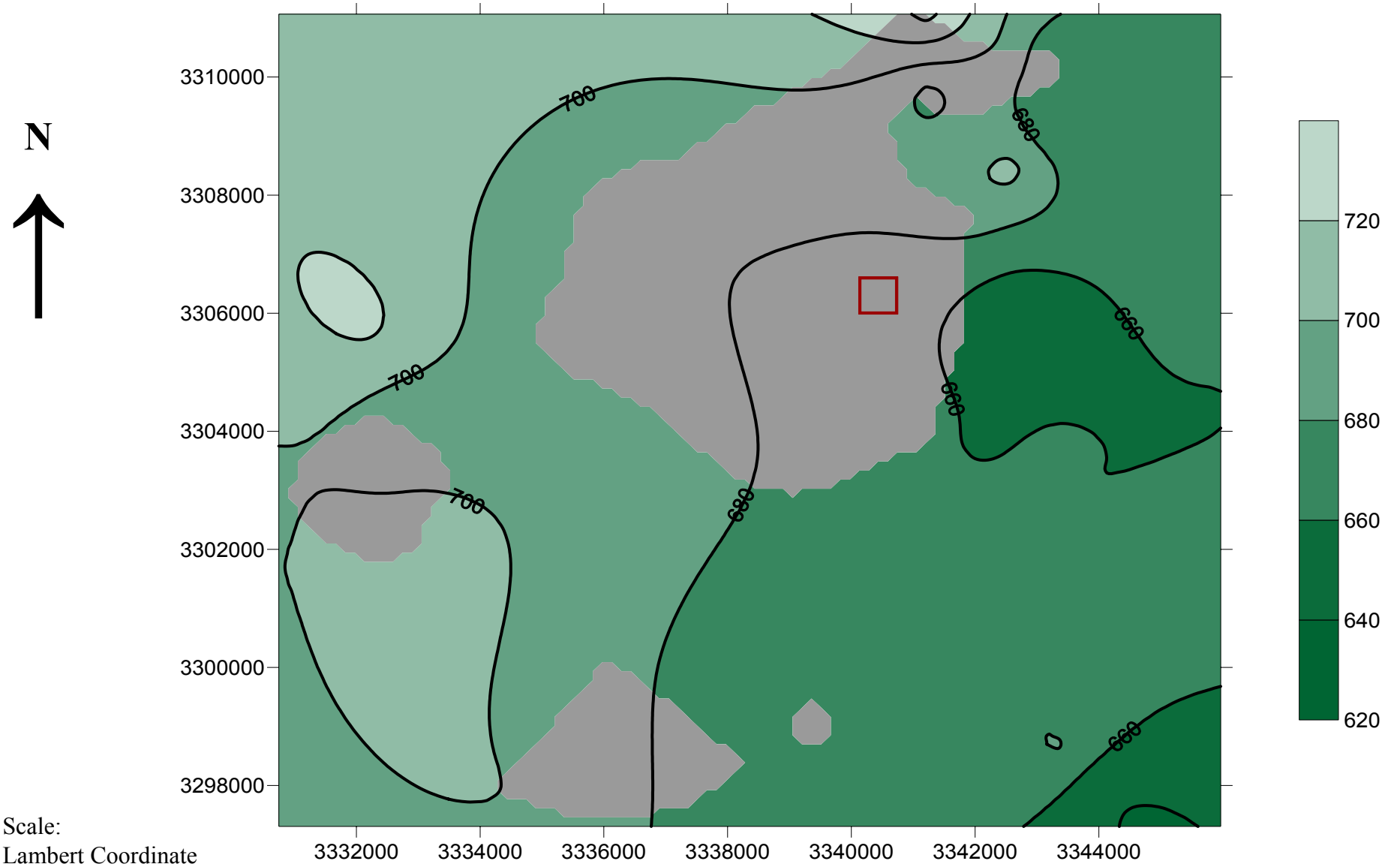
BACOG Study Area Bedrock Topography

Contour Interval = 50 Feet



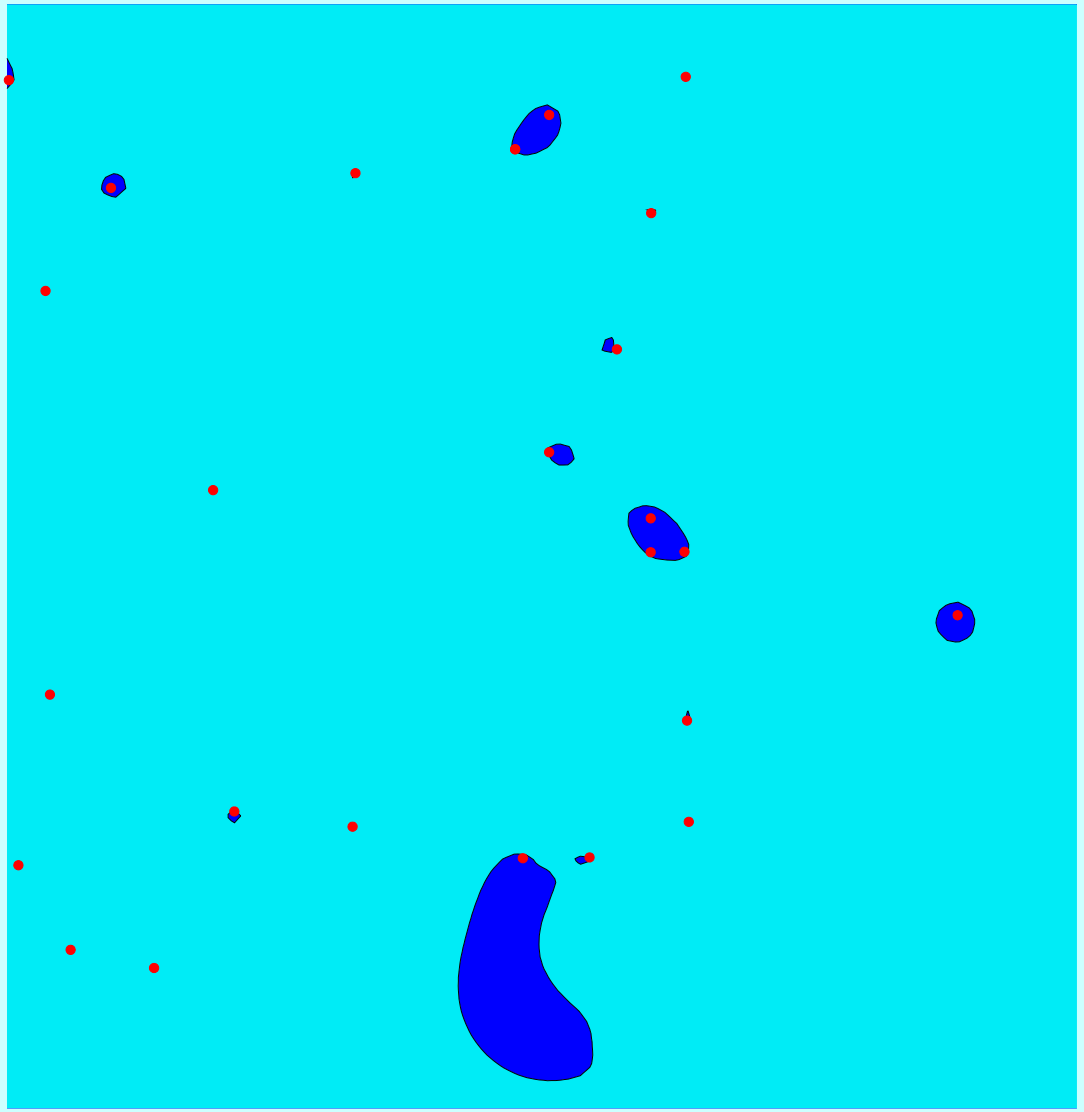
Basal Aquifer Thickness (Isopach)

Contour Interval: 20 feet



Basal Aquifer Topography

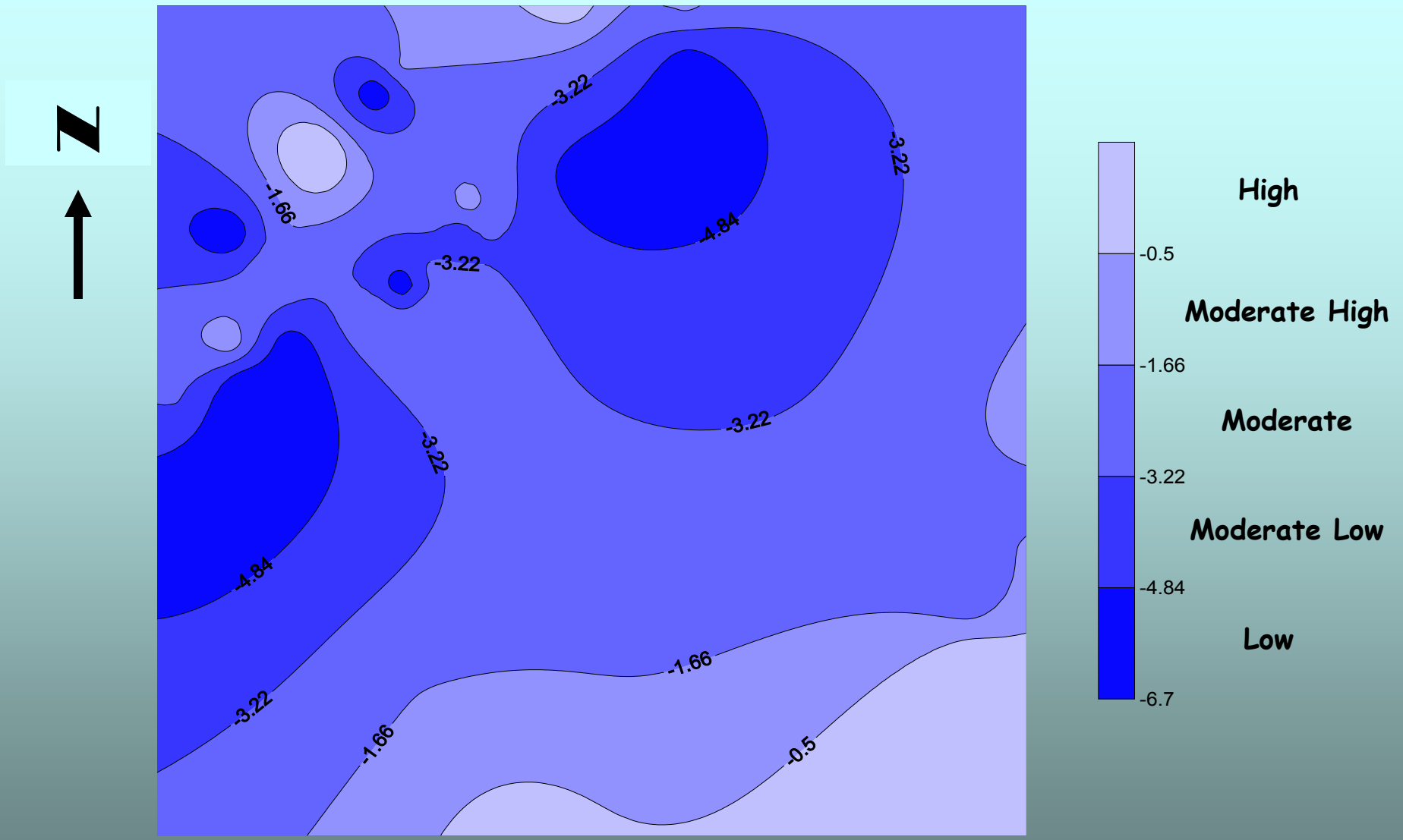
Contour Interval = 20 feet



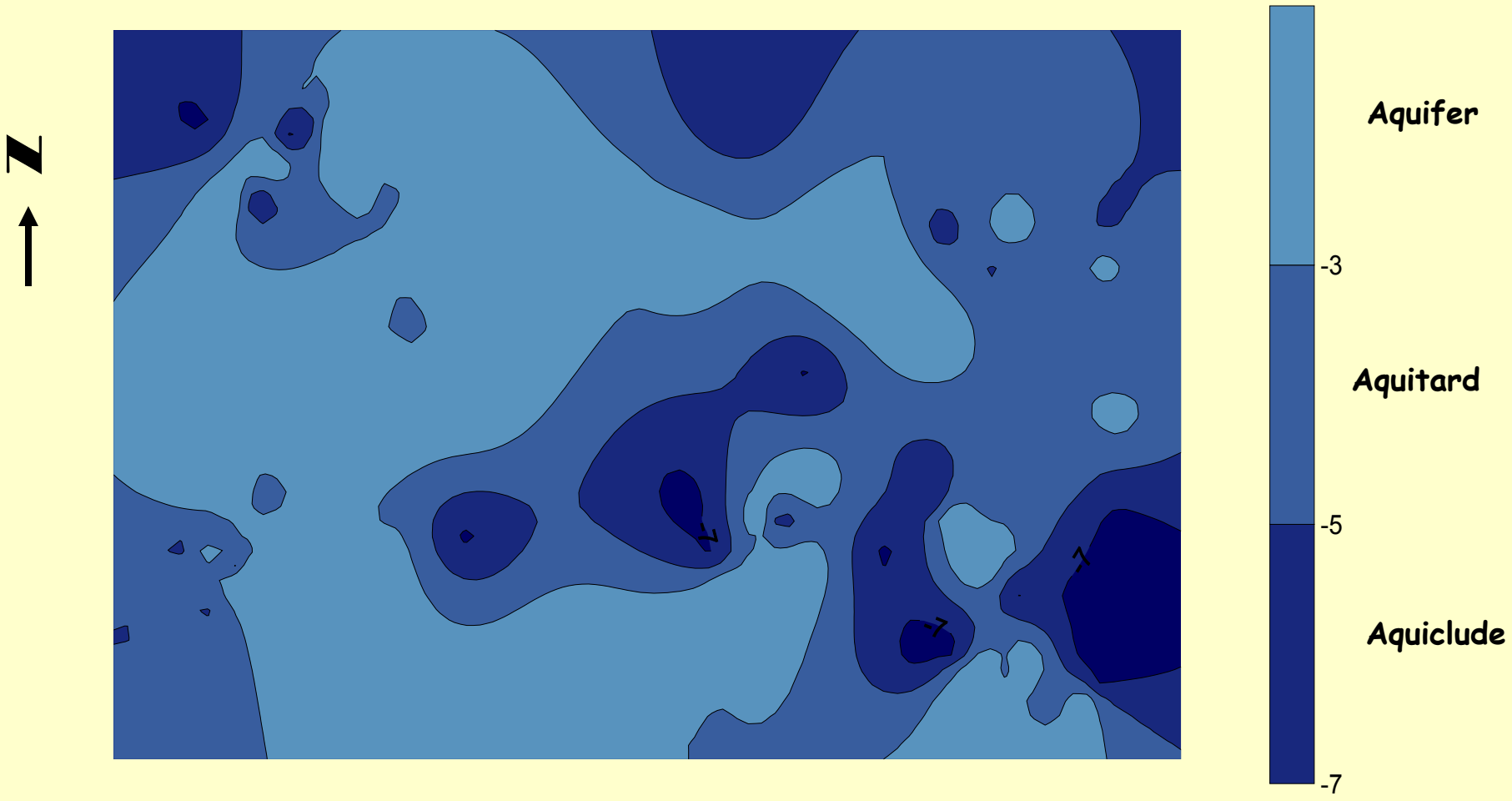
Basal Aquifer
Recharge Locations

Basal Aquifer
Recharge Areas

Basal Aquifer Recharge Locations and Areas



Recharge Potential Zones



Hydrogeologic Units Based on Distribution of Average Hydraulic Conductivity

Ground Surface

Vadose Zone Aquiclude Material

Vadose Zone Aquitard Material

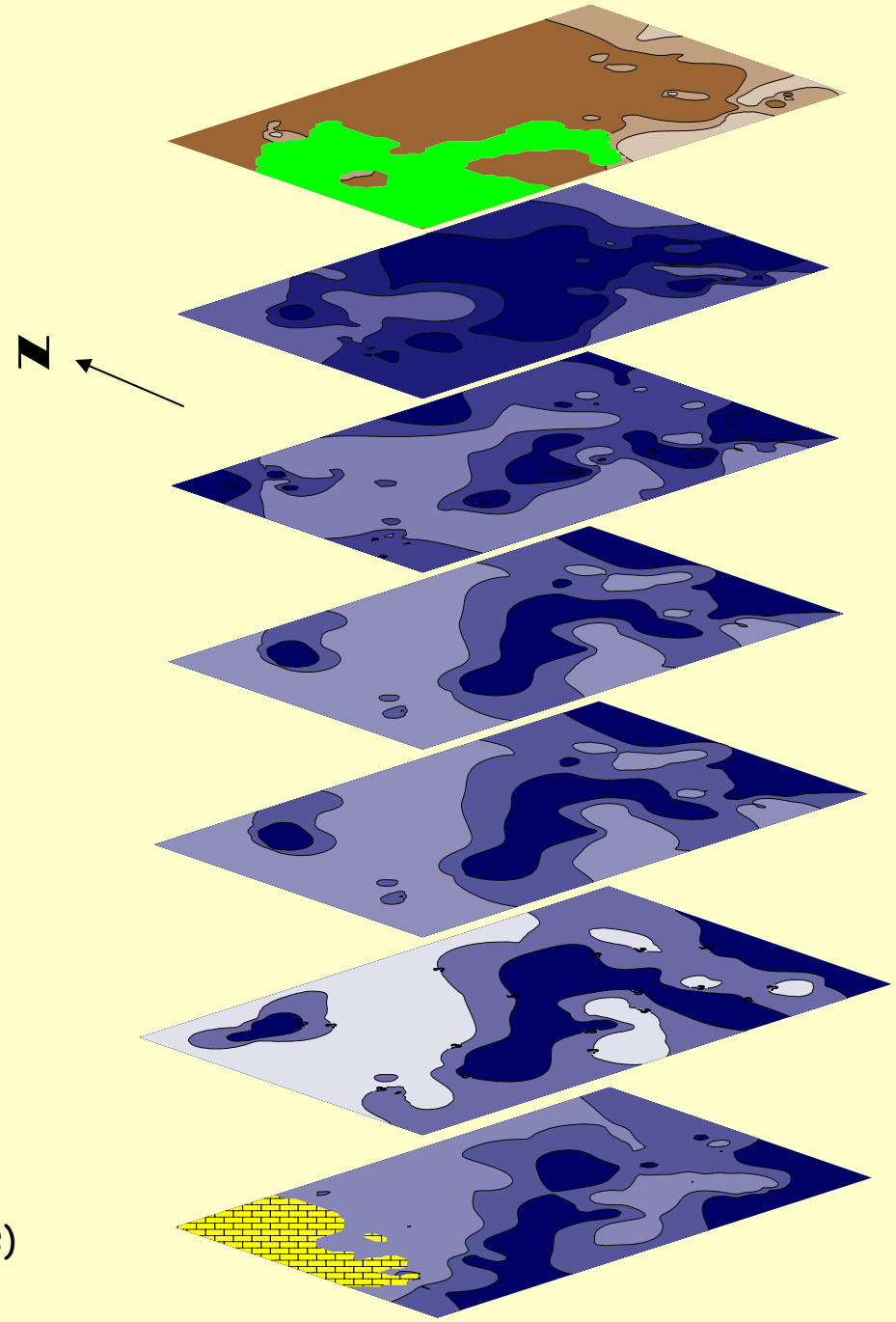
Vadose Zone Aquifer Material

Aquiclude

Aquitard

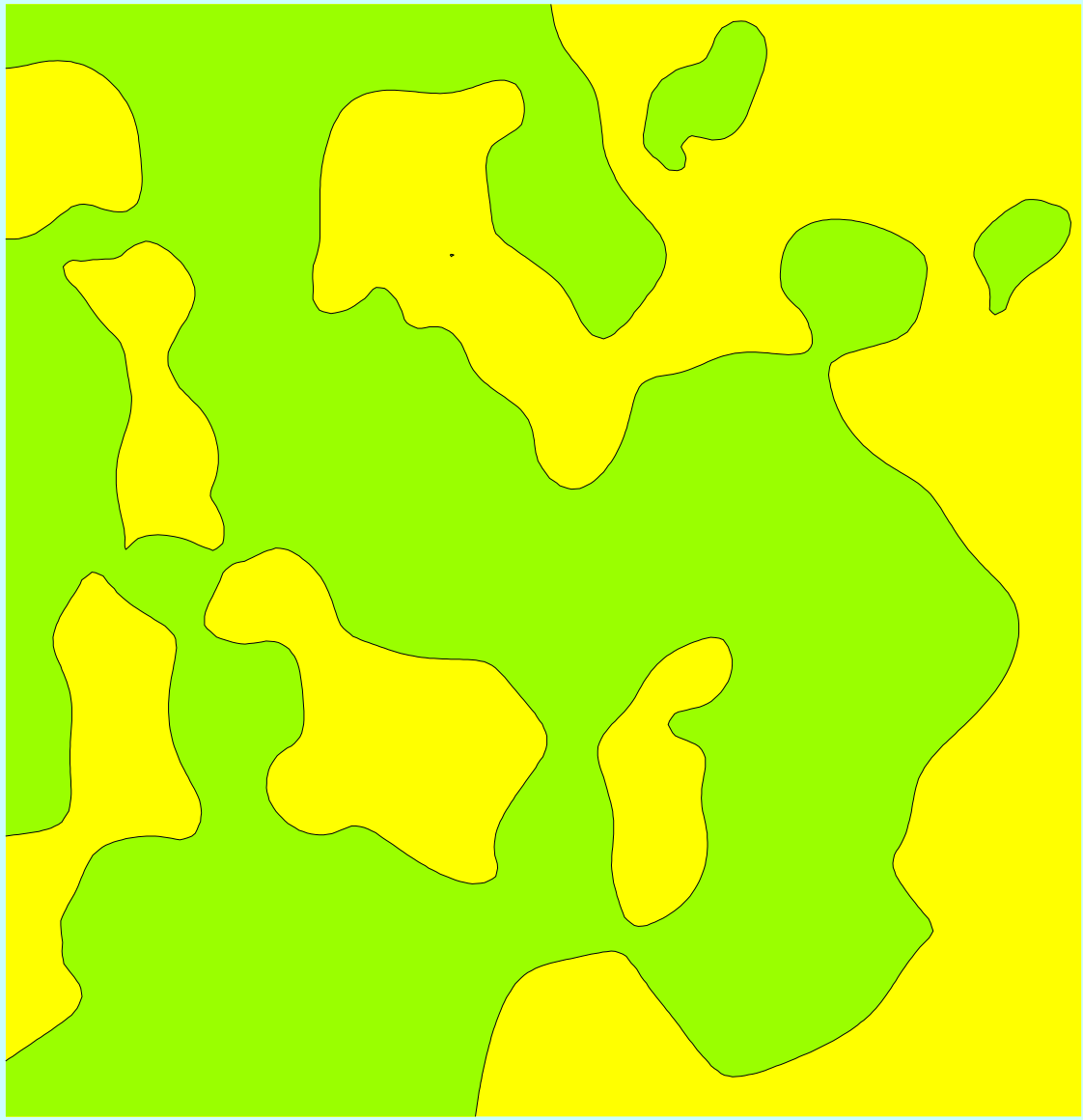
Aquifer

Bedrock

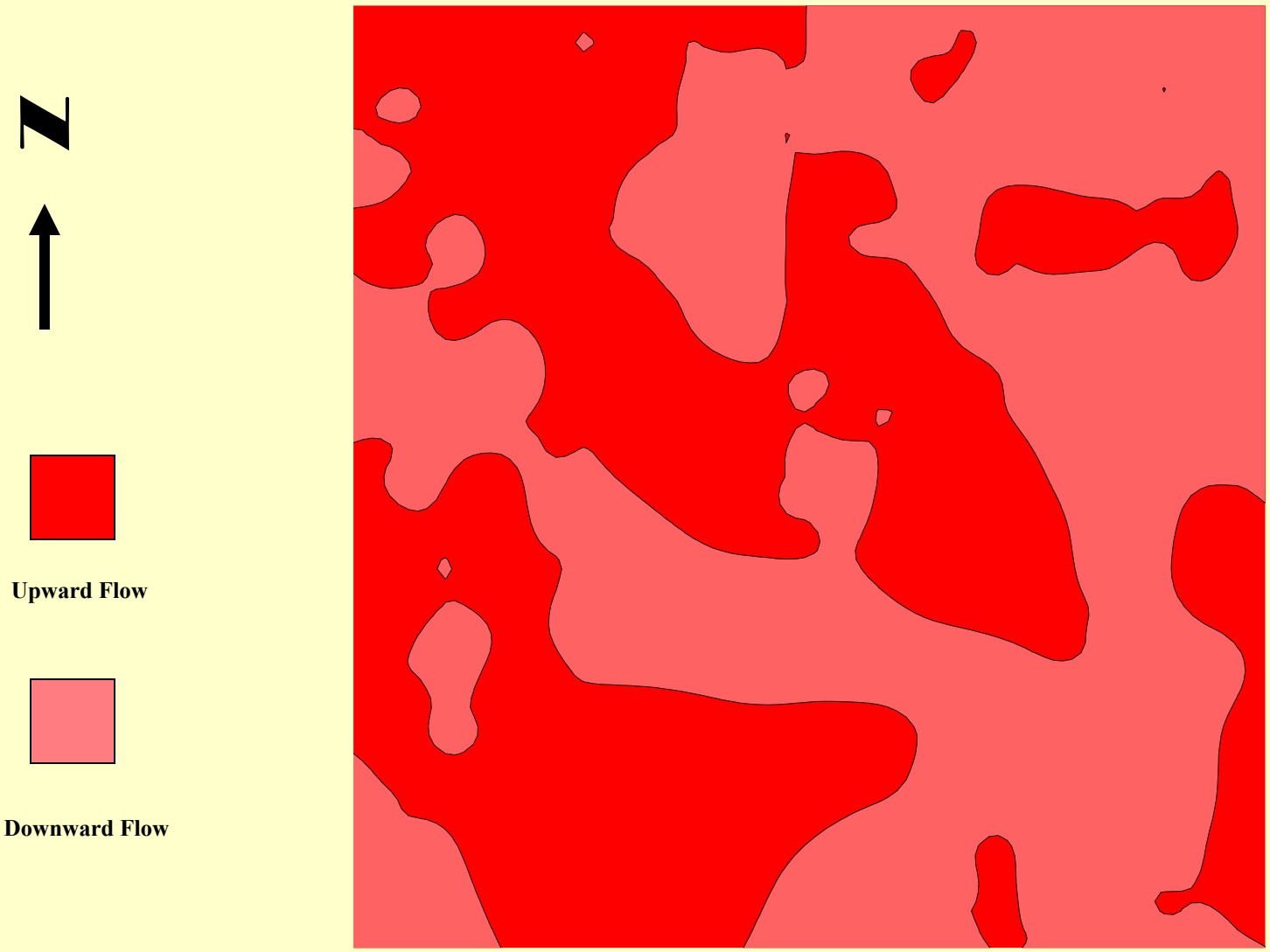


Study Area Stack-Map

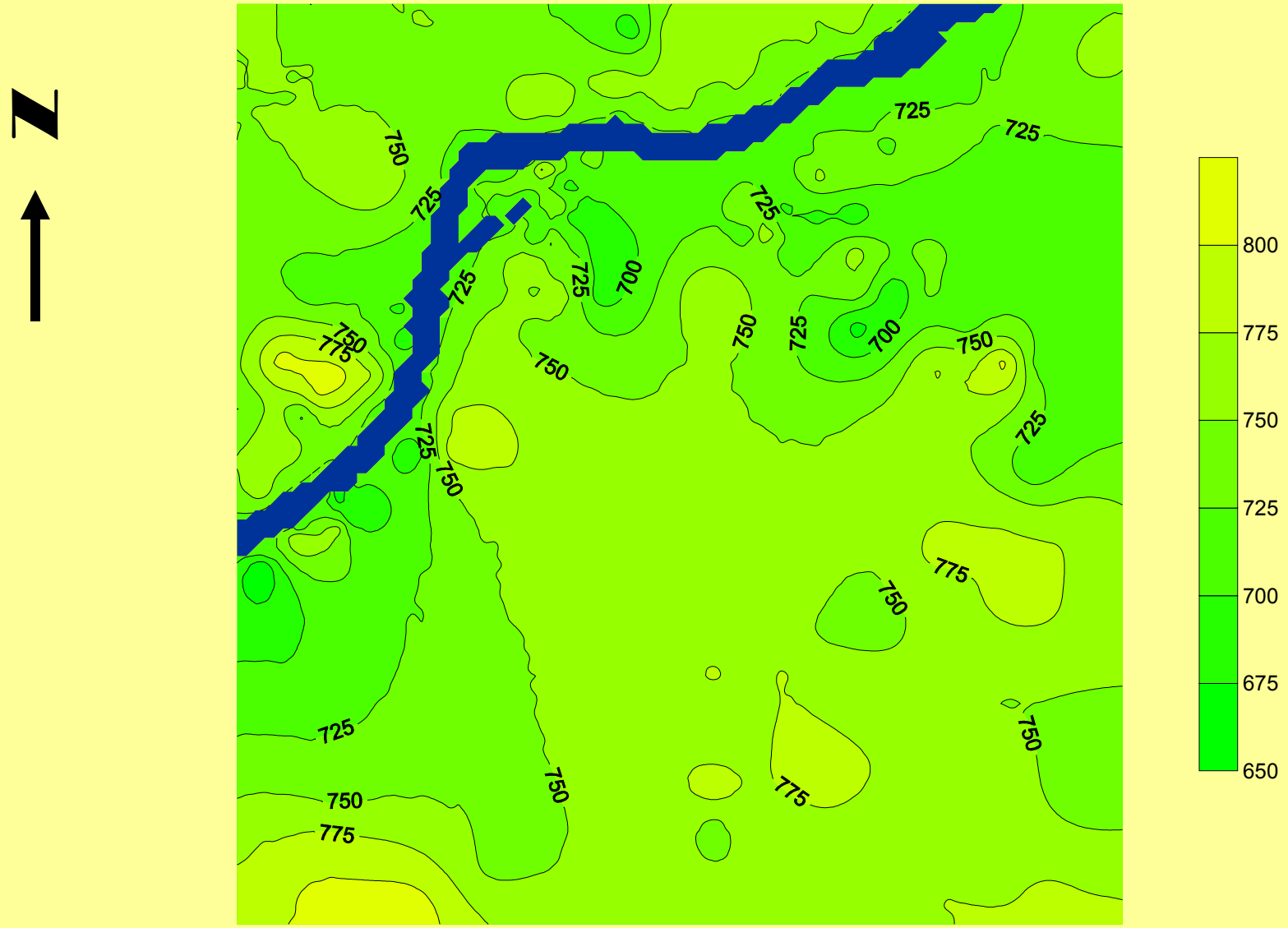
(760 to 620 feet – 20-foot Layers)



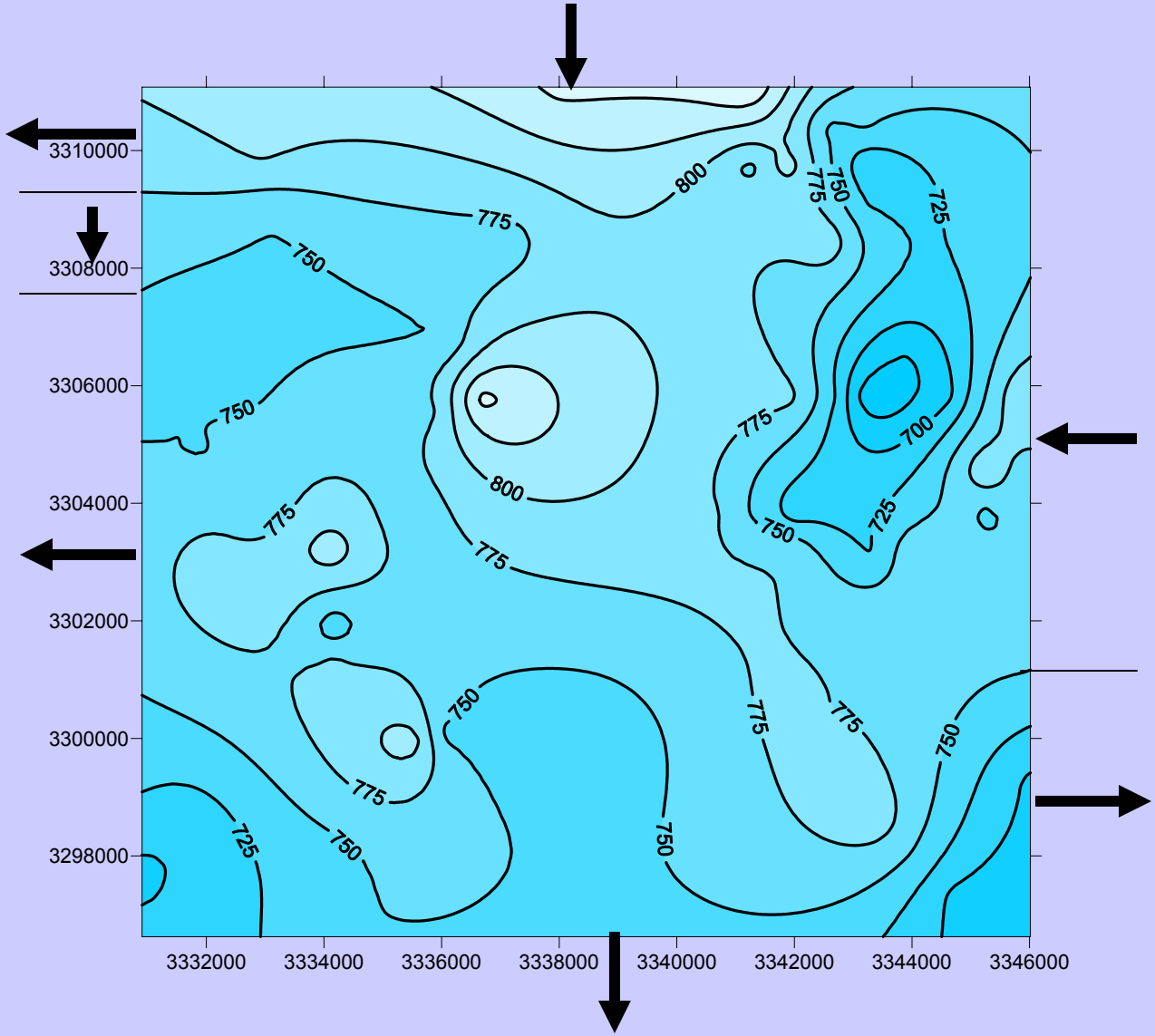
Seepage Between the Bedrock Aquifer and The Basal Aquifer



Vertical Groundwater Flow Between the Basal Aquifer and the Drift Aquifer



Potentiometric Map



Scale:

Lambert Coordinate System in Feet

Groundwater Inflow and Outflow at Study Area Boundaries

Contour Interval = 25 feet

Cross-Section of Study Area West Boundary

Aquifer

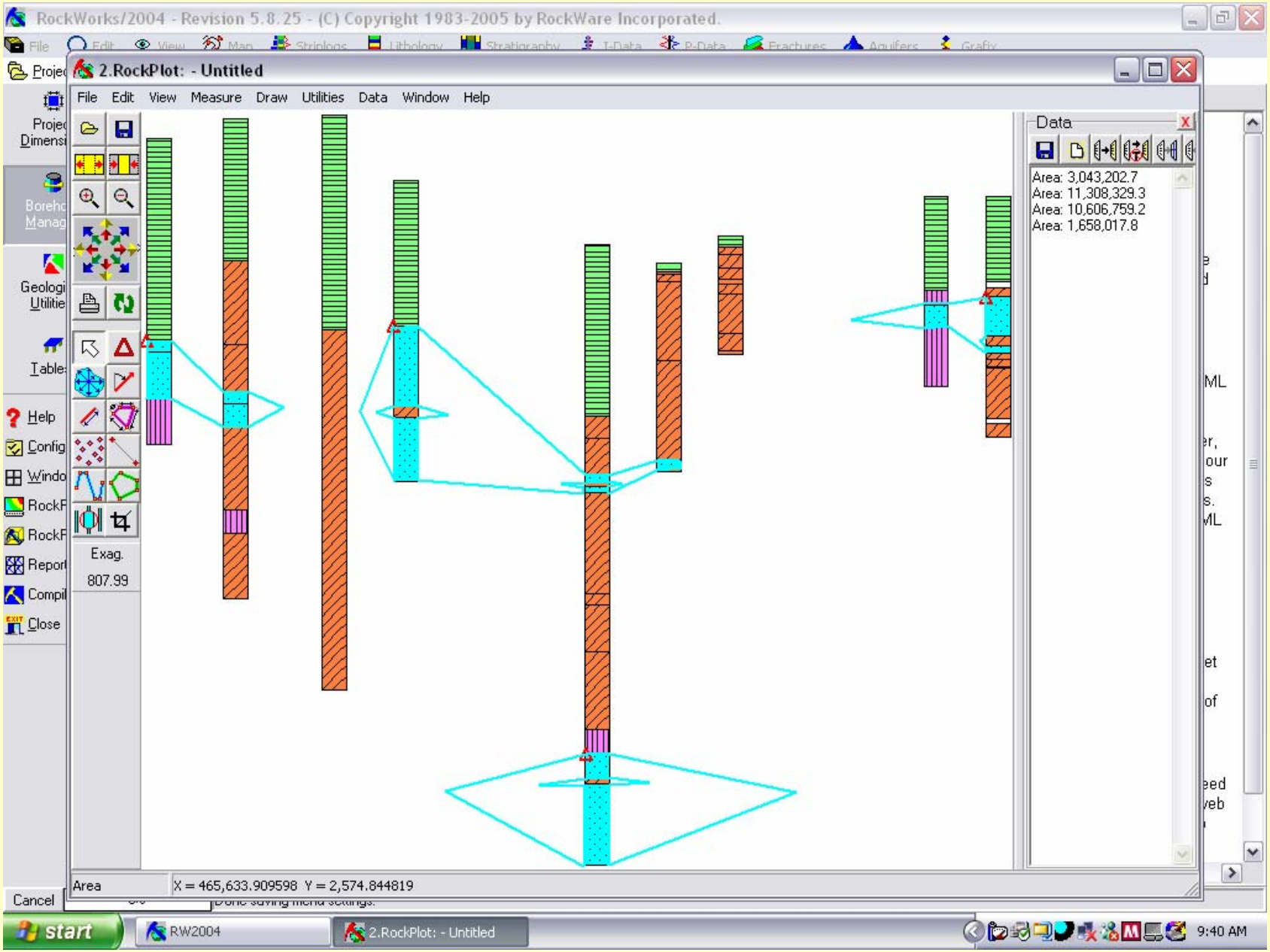
Aquitard

Aquiclude

Bedrock

Groundwater Outflow

Parallel Groundwater Flow



RockWorks 2004 Window with Polygons Used to Estimate Cross-Sectional Aquifer Area