Groundwater Flow Modeling

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Data, Information, Model

Hydrogeology:
- Piezometric mapping
- Aquifer testing (Conductivity, etc)
  → Hydrogeologic Model

Surface Water:
- Location, Width, Depth
- Diversions/Discharge
- Stream Gauge
  → Flow Accounting Model
  → Streamflow Probability

Groundwater Flow Model

Assimilate / Understand
Quantify
Predict

Physics:
- Mass/Energy
- Flow in Porous Media
  → Governing Equations

Other:
- Soil Type
- Land Cover
- Tile/Storm Drains
  → Supporting Data

Geology:
- Boring logs
- Geophysical Surveys
- Interpolation
  → Stratigraphic Model

Well Data:
- Depth
- Water Levels
- Pumping Rates
  → History/Projection

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Groundwater Flow Model
Finite Difference Block

Inflow – Outflow = Change in Storage
Finite Difference Grid

Leads to many equations, solved together

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Groundwater Flow Model

Result: Hydraulic head at each block center

Result: Groundwater flow rate between blocks
Model Analyses
Groundwater Flow Model

- Conceptual Model
  - Geology, hydrology, etc.
  - Organize/interpret data
- Mathematical Model
  - Physics →
    - Governing equations
  - Boundaries/parameters
  - Yields water levels/flow rates
- Numerical Solution by Finite Difference Approach
  - Flexible, detailed representation of geology and hydrology
  - Many equations, parameters, data
  - Computer program MODFLOW
  - Output processed into head and flux maps, transient or steady-state
Groundwater Flow Model

The mathematical representation of a conceptual model of the aquifer, solved numerically on a computer to determine the distribution of hydraulic head and flows throughout the aquifer:

“The Model”
Model Confidence and Range of Results

- Predict
- Verify
- Simulate
- Calibrate

Hydraulic Head vs. Time

- Predevelopment
- Present Day

Observations at a well

- High Recharge
- Low Pumping
- Low Recharge
- High Pumping

Range

Error

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Questions the Model Can Answer

Does pumping affect streamflow?  
Where does the water come from?

Are additional measurements needed, and where?  
What are the long-term effects of current pumping?
Additional Products of the Model

- Data sets and parameter values cross-checked for consistency.
- Framework for follow-up studies of greater detail
  - Wellfield design
  - Groundwater contamination
- Data, information, and results in GIS format.
- Baseline conditions for water management.

Defines the groundwater resource and adds to the scientific basis for water supply planning.
For this Study, Models on Two Scales:

- **Regional Model**
  - Approx. 800,000 nodes
  - Min grid spacing 2,500 ft.
  - All aquifers

- **Local Model**
  - Approx. 1.5 million nodes
  - Min grid spacing 660 ft.
  - Shallow aquifers only

For consistency and realism, the local model takes its boundary conditions from the regional model.