Pumping Tests and Hydrogeologic Data

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Topics

- Well and aquifer basics
- Pumping tests
- Data analysis
- Projecting well performance
Water Well 101

- Water level in well is lower than water level in aquifer
- Greater well drawdown results in greater flow
- Well yield and drawdown can be predictable
Hydrogeologic Terms

- Static Water Level (SWL)
- Pumping Water Level (PWL)
- Drawdown (PWL) – (SWL) = s
- Available Drawdown (Max PWL) – (SWL)
Principal Types of Aquifers

- **Alluvial**
  - Unconsolidated
  - Type III

- **Bedrock**
  - Consolidated
  - Type II

- **Confined**
  - Frequently consolidated
  - Type I
Pumping Test Objectives

- Measure flow rate and water level
- Determine yield for permanent pump setting
- Collect aquifer data
- Pumping development (remove fines)
- Water rights (document use rate)
Manners of Well Testing

- Pumping (submersible, turbine, etc.)
- Airlift (Baski)
- Bailer (Low flow rate)
- “Slug” (only for aquifer properties)
Pumping Test Field Measurements

• Flow rates
  – Totalizing flow meter, instantaneous flow meter, orifice, flume/weir, 5-gallon bucket
  – Stop watch
  – Redundant

• Water levels
  – M-.Scope, pressure transducer, airline, sounder
  – Redundant
  – 1” PVC tube(s) for easy access downhole
Dan’s Six Pump Test Essentials

1. M-Scope
2. 5-gallon bucket
3. Stopwatch
4. 2 pens
5. Notepad
6. Calculator
Measurements and Observations

- Well construction
  - Borehole depth, diameter
  - Casing and screen size diameter
  - Screened interval
- SWL, PWL’s
- Recovery WL’s *** especially for low yield wells ***
- Observation well WL’s (Nearby Wells)
- Total well depth before and after testing
- Flow rates
- Sand production
- Color of discharge
- Location of discharge
- Water quality
- Temperature
- Weather
- Time, date
- Nearby streams, ditches, etc.

You only get one chance to document a pumping test!
Constant-Discharge Pumping Test

- Easiest to data to evaluate because only WL’s change
- Constant flow during duration of test (<10% change)
- Most water level change occurs early in test
- Measure flow rate and water levels at specific intervals
  - 1 to 10 minutes: Every 1 minute
  - 10 to 20 minutes: Every 2 minutes
  - 20 to 50 minutes: Every 5 minutes
  - 50 to 90 minutes: Every 10 minutes
  - 1.5 to 4 hours: Every ½ hour
  - 4 to 24 hours: Every 1 hour
- Most important: Write down WHEN the measurement is collected, even if it is late
Constant Discharge Pumping Test
Linear Graph (24 – hours)

675 gpm
Arapahoe Aquifer
Constant Discharge Pumping Test
Semi-Log Graph (24 – hours)

675 gpm
Arapahoe Aquifer
Constant Discharge Pumping Test
Log-Log Graph (24 – hours)

675 gpm
Arapahoe Aquifer
Consistent Response for Longer Pumping Periods (7 – days)

150 gpm
Arapahoe Aquifer
Step Pumping Test

40 gpm, 70 gpm, 100 gpm
Lower Arapahoe Aquifer
Water Level Recovery

![Graph showing water level recovery over time. The x-axis represents time since pumping stopped in minutes, ranging from 0 to 2500. The y-axis represents residual drawdown in feet, ranging from 100 to 0. The graph includes pink data points indicating water level below the top of the casing in feet.](image-url)
**Ideal Aquifer Trend**
- Gradual increase in drawdown

**Recharge Trend**
- Water level stabilizes

**Fractured Rock Aquifer Trend**
- Water level does not stabilize

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_Bishop-Brograden Associates, Inc._
Constant Discharge Pumping Test (80 – minutes)

25 gpm
Mountain Alluvial Aquifer
Plot Data in the Field

- Identify for trends
- Watch out for changes in trends
Plot Data in the Field (cont.)

Projected Drawdown

Drawdown (ft)

Time (min)

30  60  90  120

10  20

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Uh-Oh!

Whew! OK.

Projected Drawdown
Well Performance Projections

Estimate drawdown for different pumping rates using calculated transmissivity and storativity.
Well Performance Projections

Same data graphed semi-log
Well Performance Projections

Estimate drawdown for different pumping periods using calculated transmissivity and storativity
Specific Capacity

Simple Measure of Well Efficiency

- \( \frac{\text{Pumping Rate}}{\text{Drawdown}} = \frac{Q}{s} \)
- Compare pumping tests at different pumping rates
- Evaluate changes in well efficiency
- Forecast drawdown at different pumping rates
  - Pump sizing
- Limitation: need to compare \( \frac{Q}{s} \) at same time after pumping begins
  - E.g. \( \frac{Q}{s} \) at 4 hours
  - E.g. \( \frac{Q}{s} \) at 12 hours
Specific Capacity

Pumping Rate = 100 gpm
Specific Capacity

- Say well test at 15 gpm with 100 ft drawdown after 4 hours: \( \frac{15 \text{ gpm}}{(100 \text{ ft})} = 0.15 \text{ gpm/ft} \)

Then, how much drawdown at 5 gpm after 4 hours?
\( \frac{5 \text{ gpm}}{0.15 \text{ gpm/ft}} = 33 \text{ ft drawdown} \)

Say only 70 ft drawdown acceptable?
\( 70 \text{ ft} \times (0.15 \text{ gpm/ft}) = 10.5 \text{ gpm} \)
Mountain Domestic Well

- Estimate well yield in gallons per day
  - Recovery data is crucial (how long to recover to swl?)

- Compare yield with demand
  - 50 to 100 gallons per day per person demand
  - 150 to 350 gallons per day demand for a family
  - Lawn/garden irrigation at 0.1 gallons per day per square foot (conservative)

- Storage to accommodate peak demand

- Consider seasonal WL changes
SWL Changes

• Alluvial aquifers & fractured rock aquifers
  – Seasonal changes
  – Wet year vs. dry year

• Aquifers with limited recharge (Denver Basin & High Plains)
  – Regional decline
  – Irrigation season well-to-well impact
Jefferson County Mountain Water
Well Water Levels

- Large seasonal WL changes
- Wet year vs. dry year

Thank you Roy Laws
Denver Basin Water Level Decline

Appx. 38 ft/yr
Declining Denver Basin Water Levels (cont.)

- 2000 - 100 gpm
  - Pumping water level above well screens
  - Well is efficient

- 2010 - 75 gpm
  - Pumping water level top well screens
  - Well efficiency compromised

- 2015 - 50 gpm
  - Pumping water level below most well screens
  - Well efficiency significantly compromised
Confined Aquifer
Well-to-Well Interference

- Non-Pumping (Static) water level declines during summer due to well-to-well interference and recovers during winter and spring
- 175.5 ft irrigation season decline, in example
- Value to frequent water level data collection
Rules of Thumb

• Maximum drawdown
  – Alluvial and Unconfined Bedrock: 2/3 water column in well
  – Confined: 1/2 water column in well
  – Keep PWL above principal well production zone
• (Max 24-hour rate during testing) x (60%) = Safe Well Yield
• Test well at greater rate than planned permanent equipment
• Consider water level recovery
Summary

• Aquifers are predictable (not all wells are predictable!)
• Consider future static water levels
• Prepare for a successful test
  – Redundant water level and flow rate measurements
• Collect data and note the time
• Plot data by hand to understand water level trends
• There are simple ways to forecast drawdown and pumping rates