# Pumping Tests and Hydrogeologic Data

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# Topics

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

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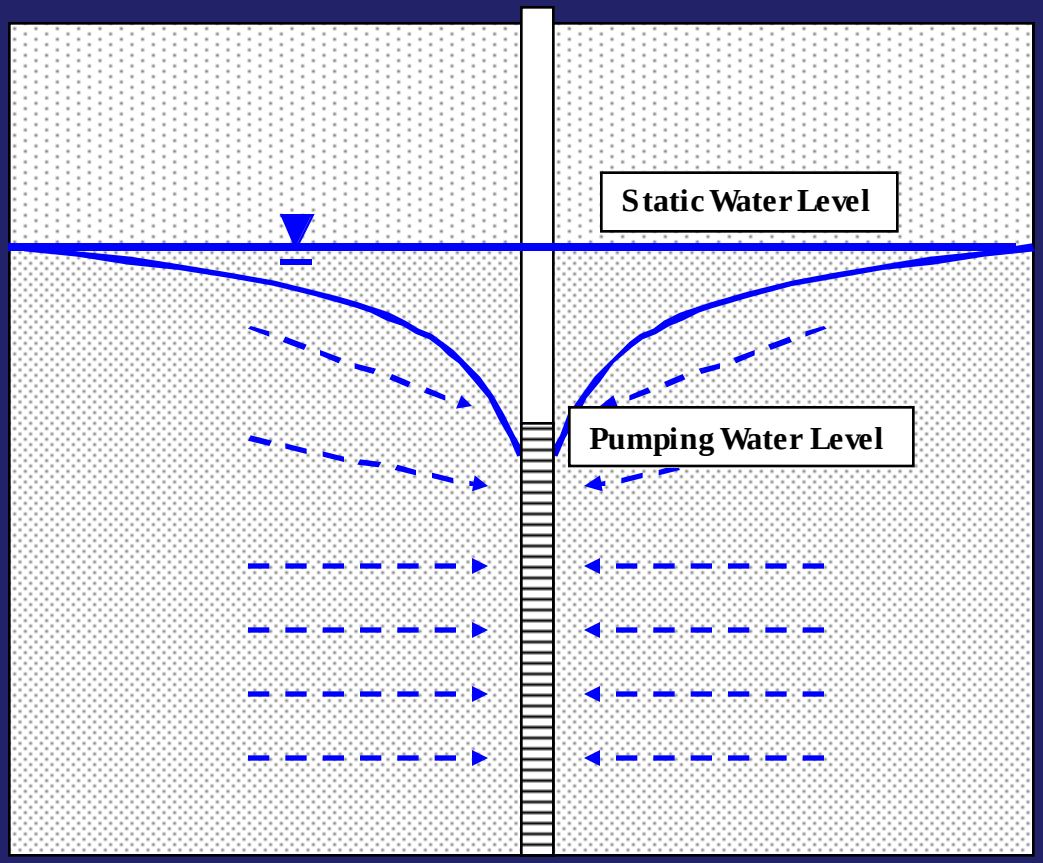
# Water Well 101




- 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

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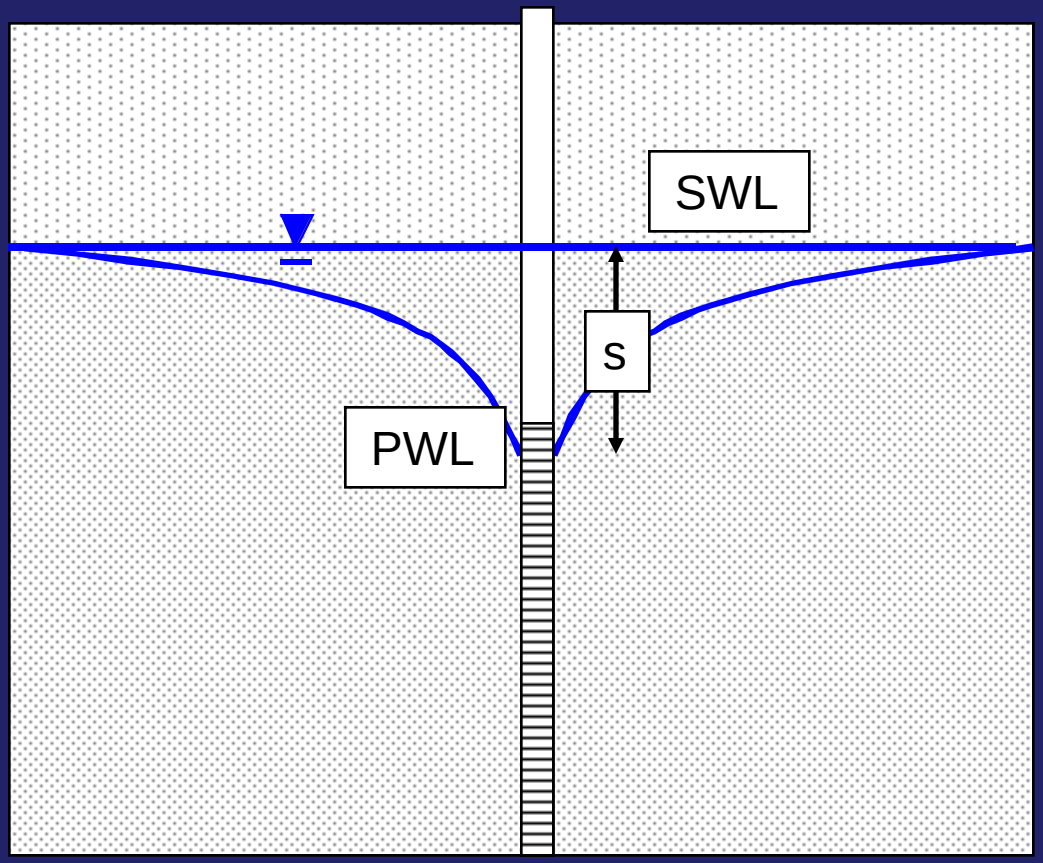
# Hydrogeologic Terms




- Static Water Level (SWL)
- Pumping Water Level (PWL)
- Drawdown (PWL) – (SWL) = s
- Available Drawdown (Max PWL) – (SWL)

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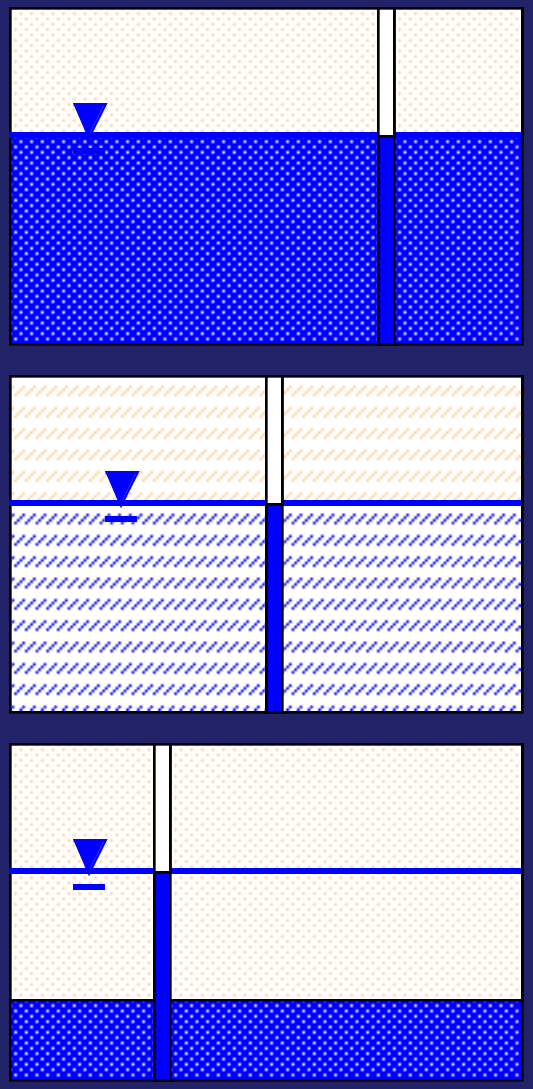
# Principal Types of Aquifers



- Alluvial
  - Unconsolidated
  - Type III
- Bedrock
  - Consolidated
  - Type II
- Confined
  - Frequently consolidated
  - Type I

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# 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)

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# Manners of Well Testing

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

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# 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

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# Dan's Six Pump Test Essentials

M-Scope

Graduated Bucket

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

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# 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!***

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# 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

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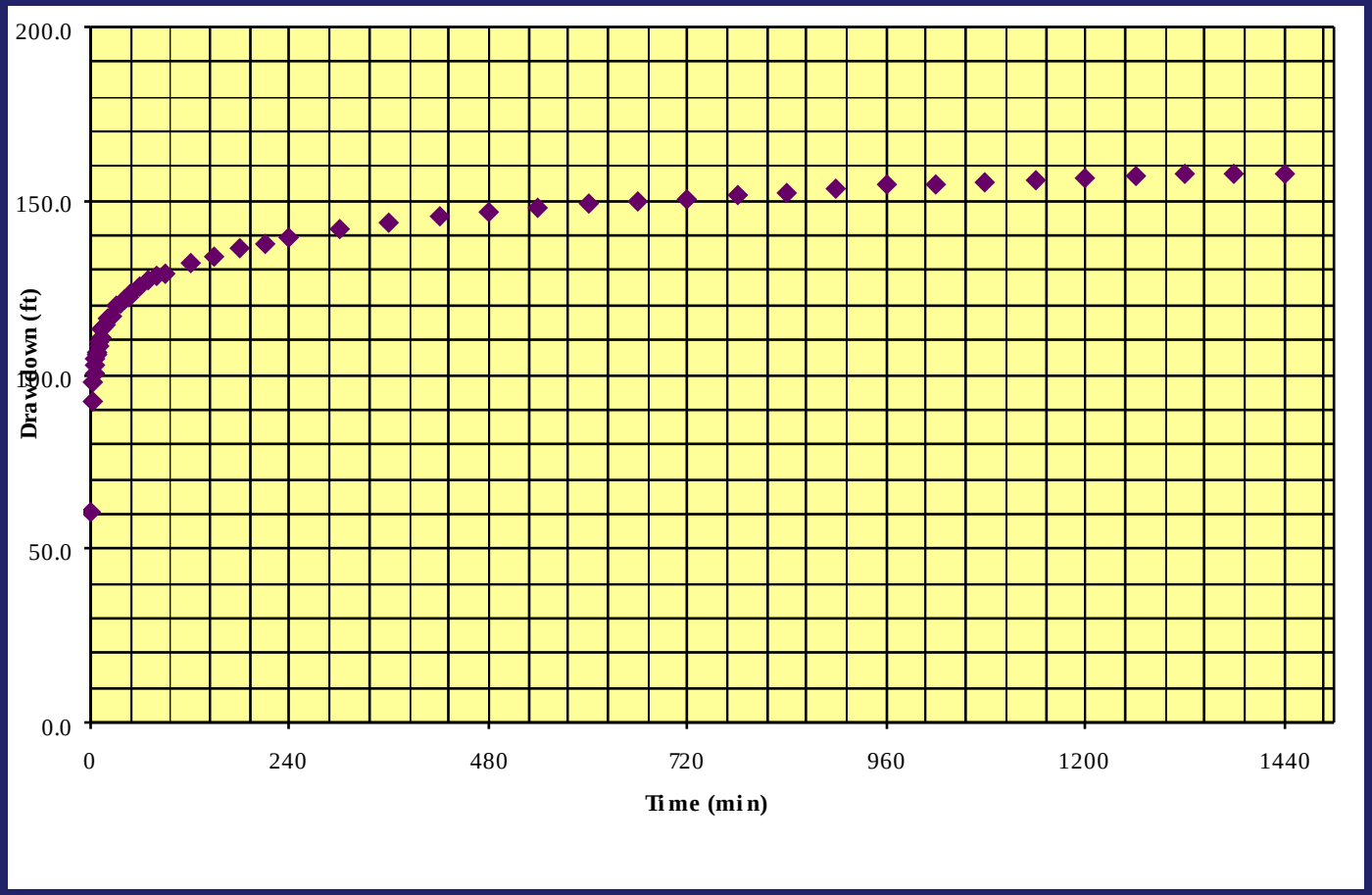
# Constant Discharge Pumping Test Linear Graph (24 – hours)




675 gpm
Arapahoe Aquifer

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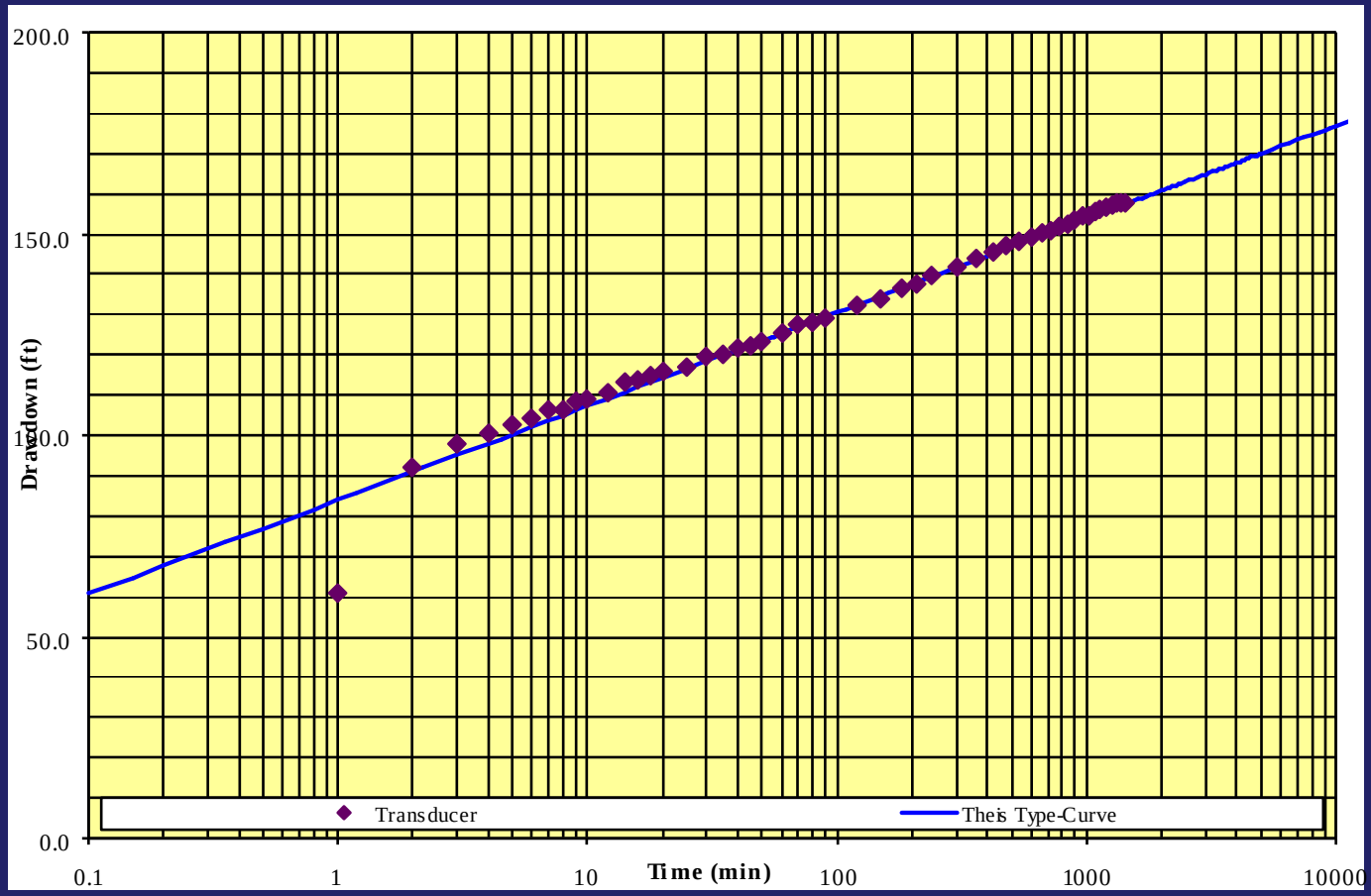
# Constant Discharge Pumping Test Semi-Log Graph (24 – hours)




675 gpm
Arapahoe Aquifer

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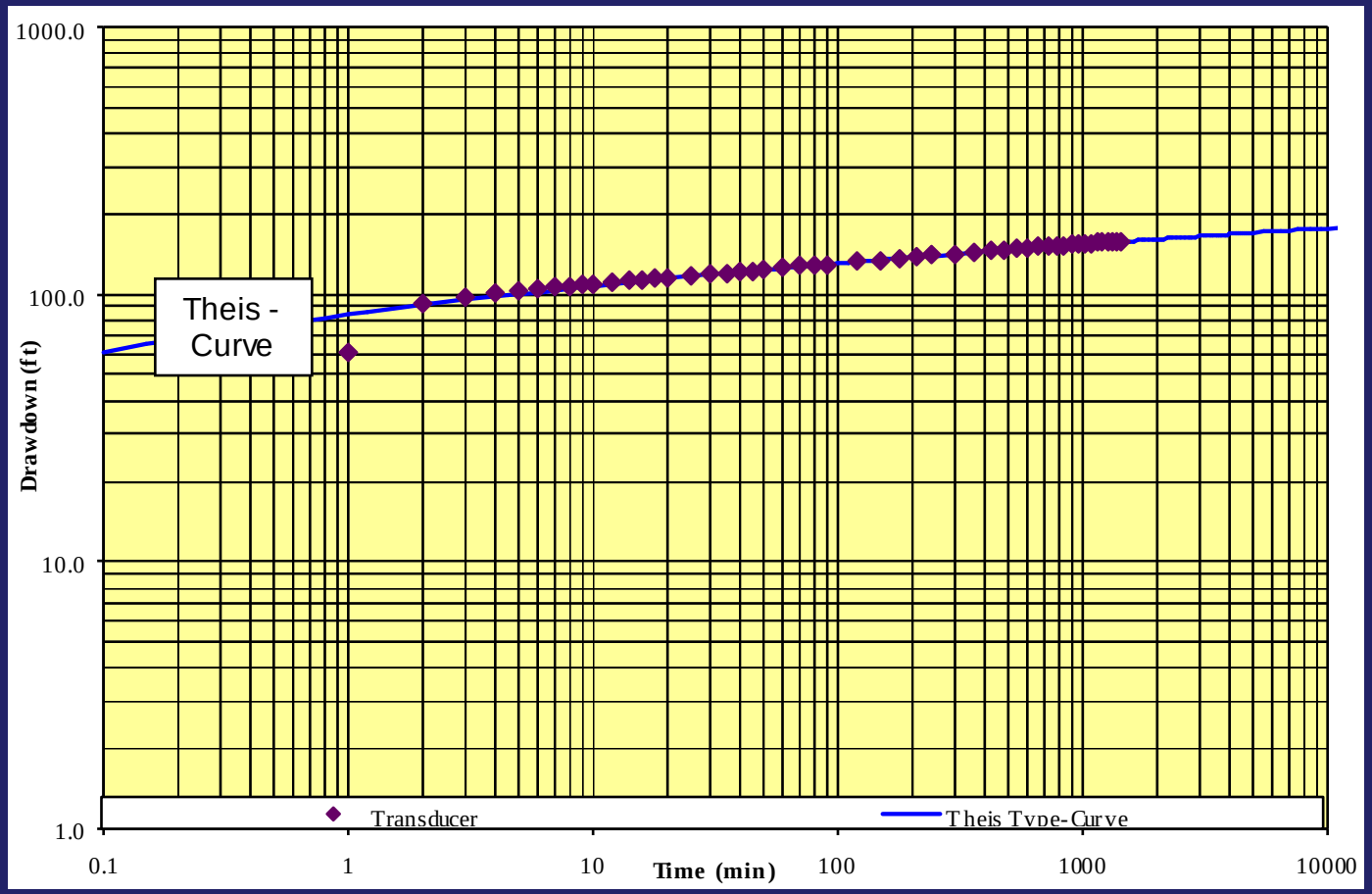
# Constant Discharge Pumping Test Log-Log Graph (24 – hours)




675 gpm
Arapahoe Aquifer

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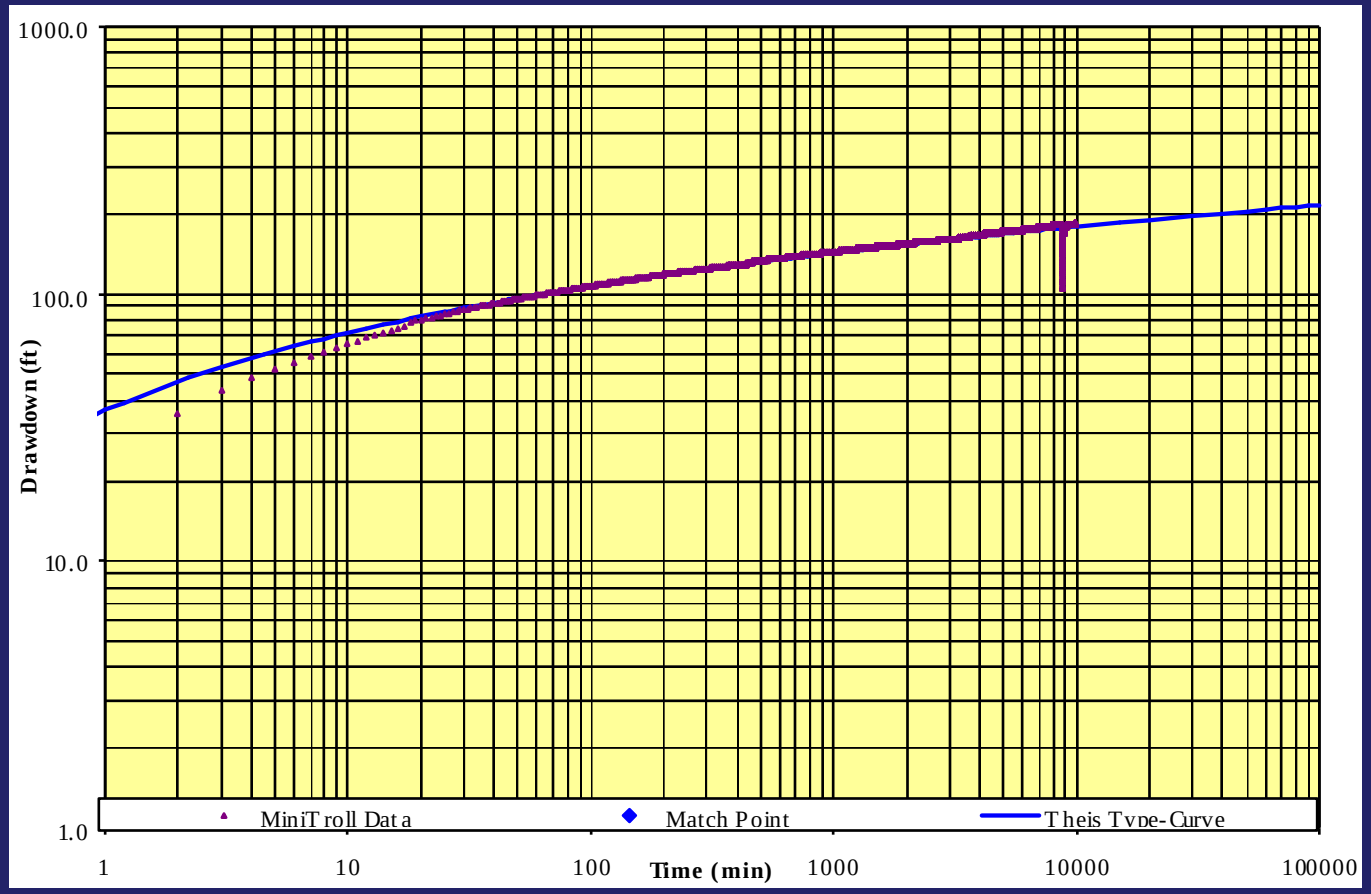
# Consistent Response for Longer Pumping Periods (7 – days)




150 gpm
Arapahoe Aquifer

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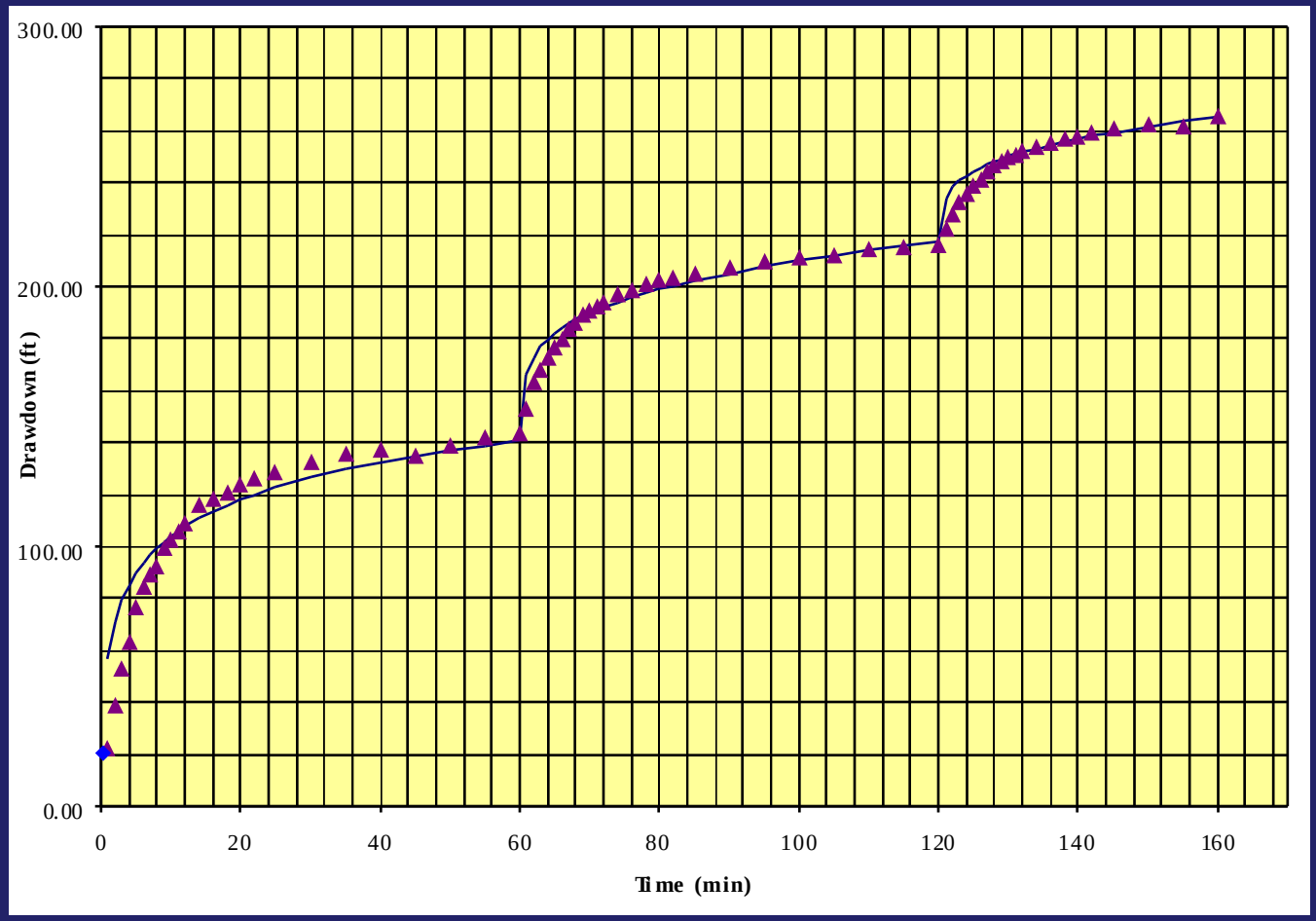
# Step Pumping Test




40 gpm, 70 gpm, 100 gpm
Lower Arapahoe Aquifer

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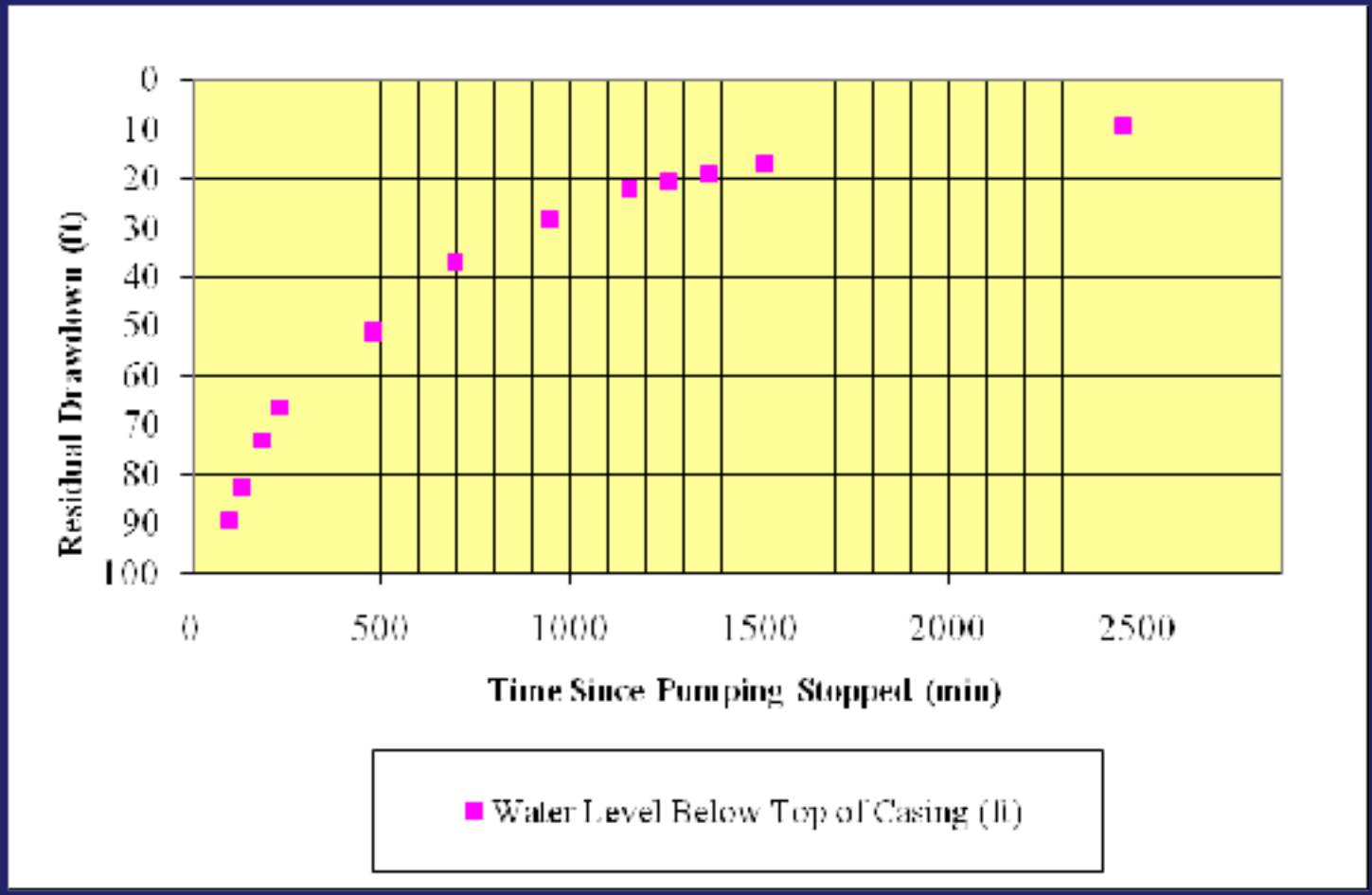
# Water Level Recovery

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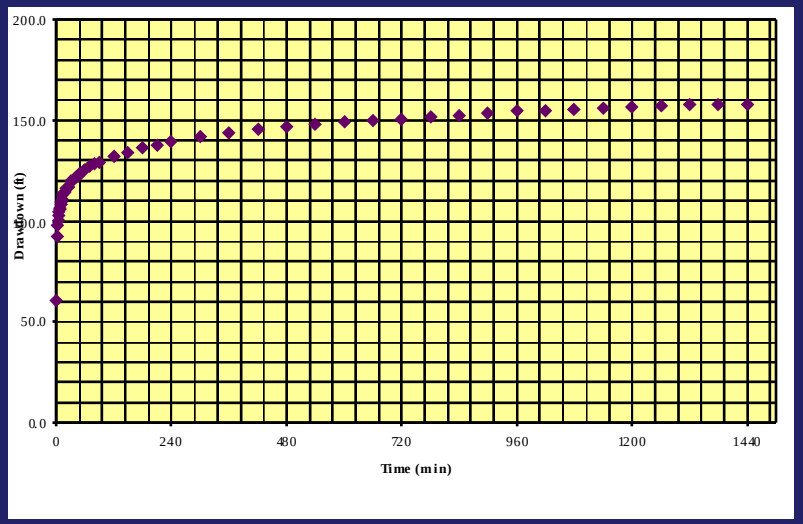
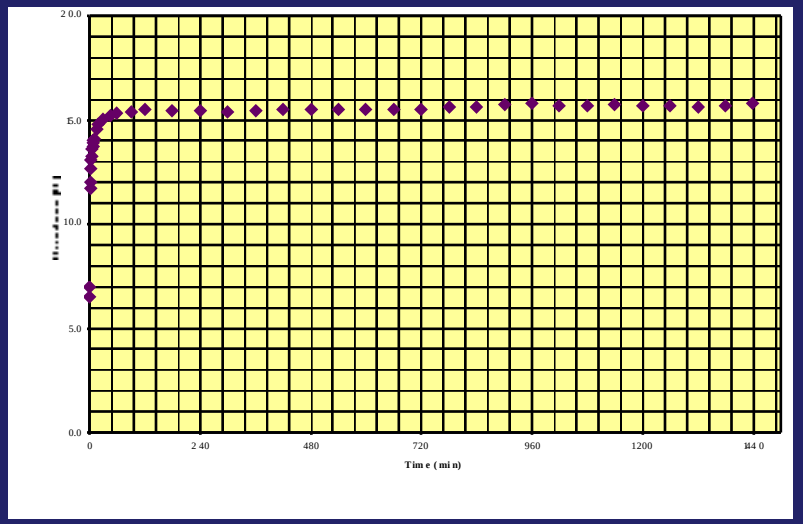
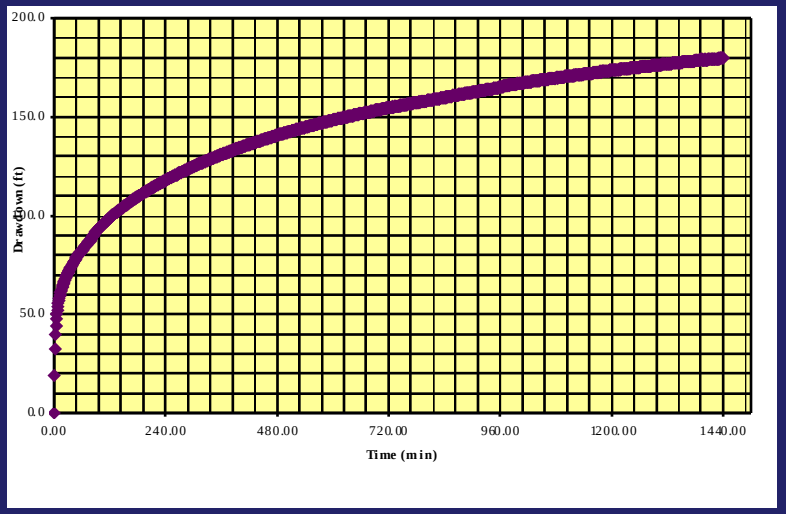



Ideal Aquifer Trend
- Gradual increase in drawdown




Recharge Trend
- Water level stabilizes




Fractured Rock Aquifer Trend
- Water level does not stabilize

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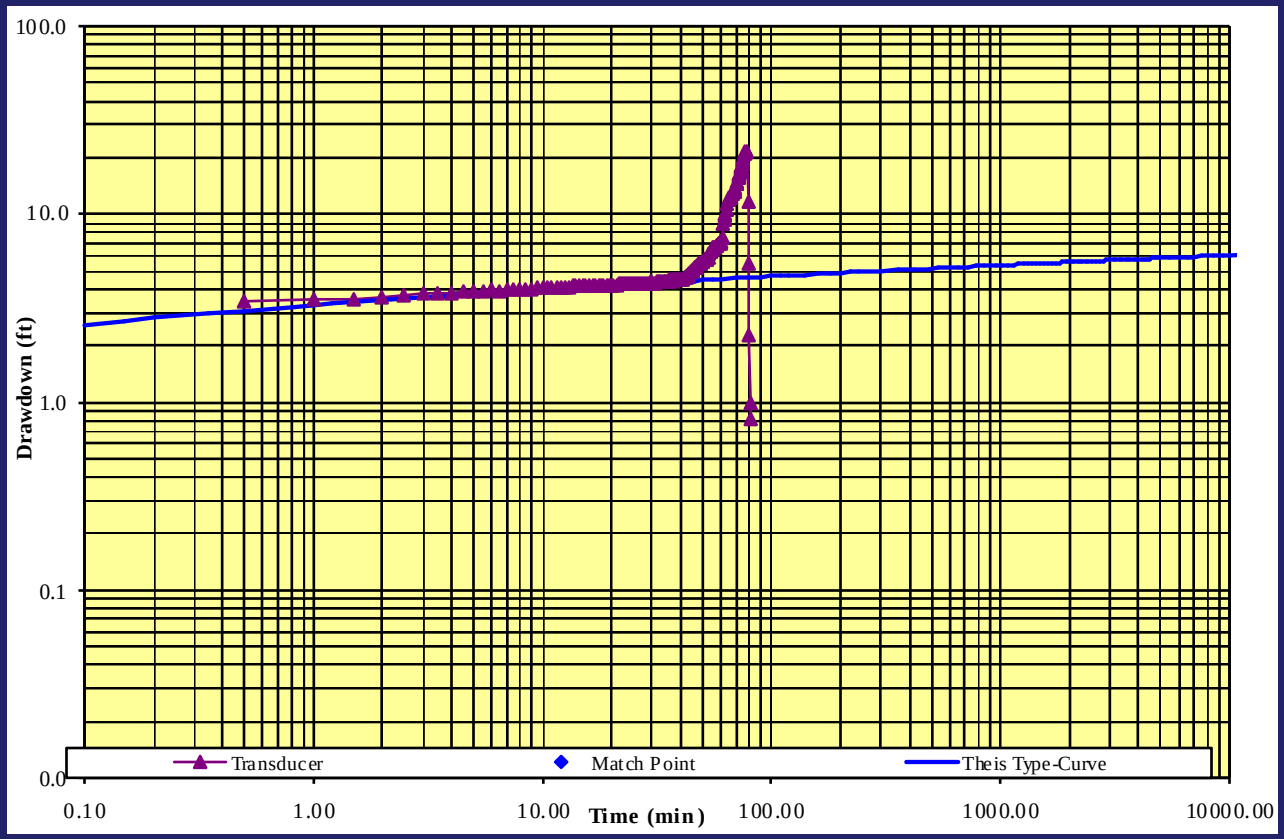
# Constant Discharge Pumping Test (80 – minutes)




25 gpm
Mountain Alluvial Aquifer

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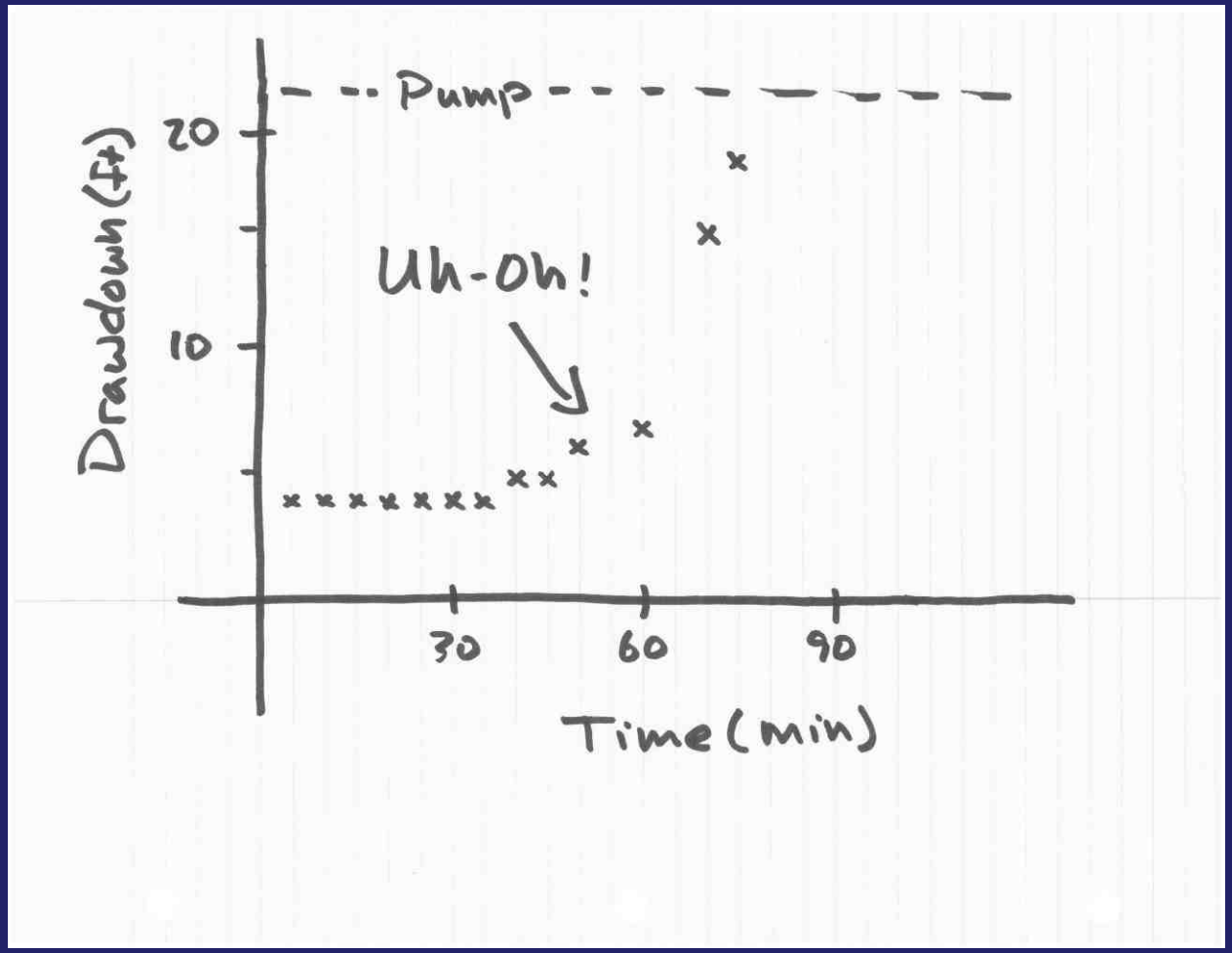
# Plot Data in the Field




- Identify for trends
- Watch out for changes in trends

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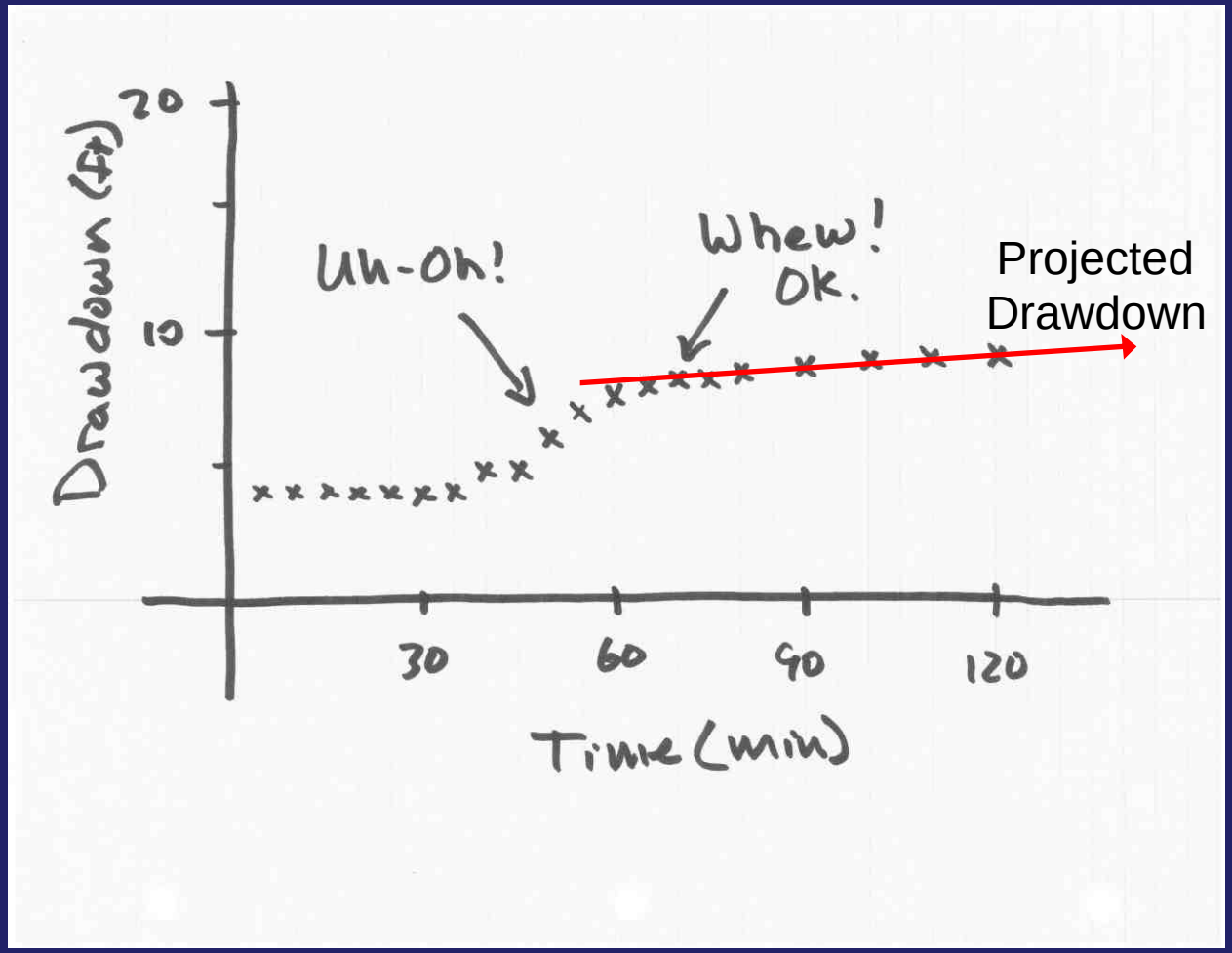
# Plot Data in the Field (cont.)

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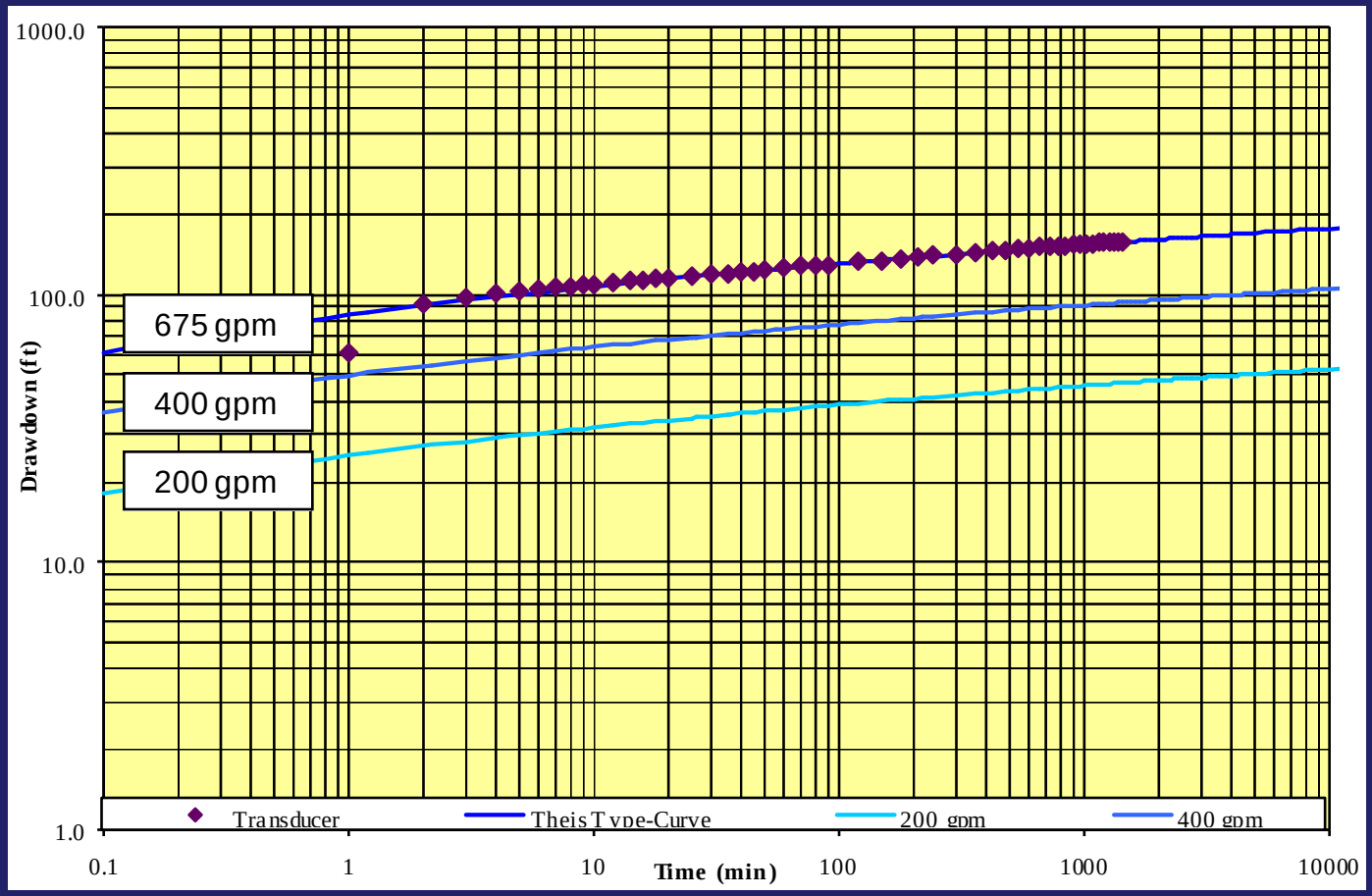
# Well Performance Projections




Estimate drawdown for different pumping rates using calculated transmissivity and storativity

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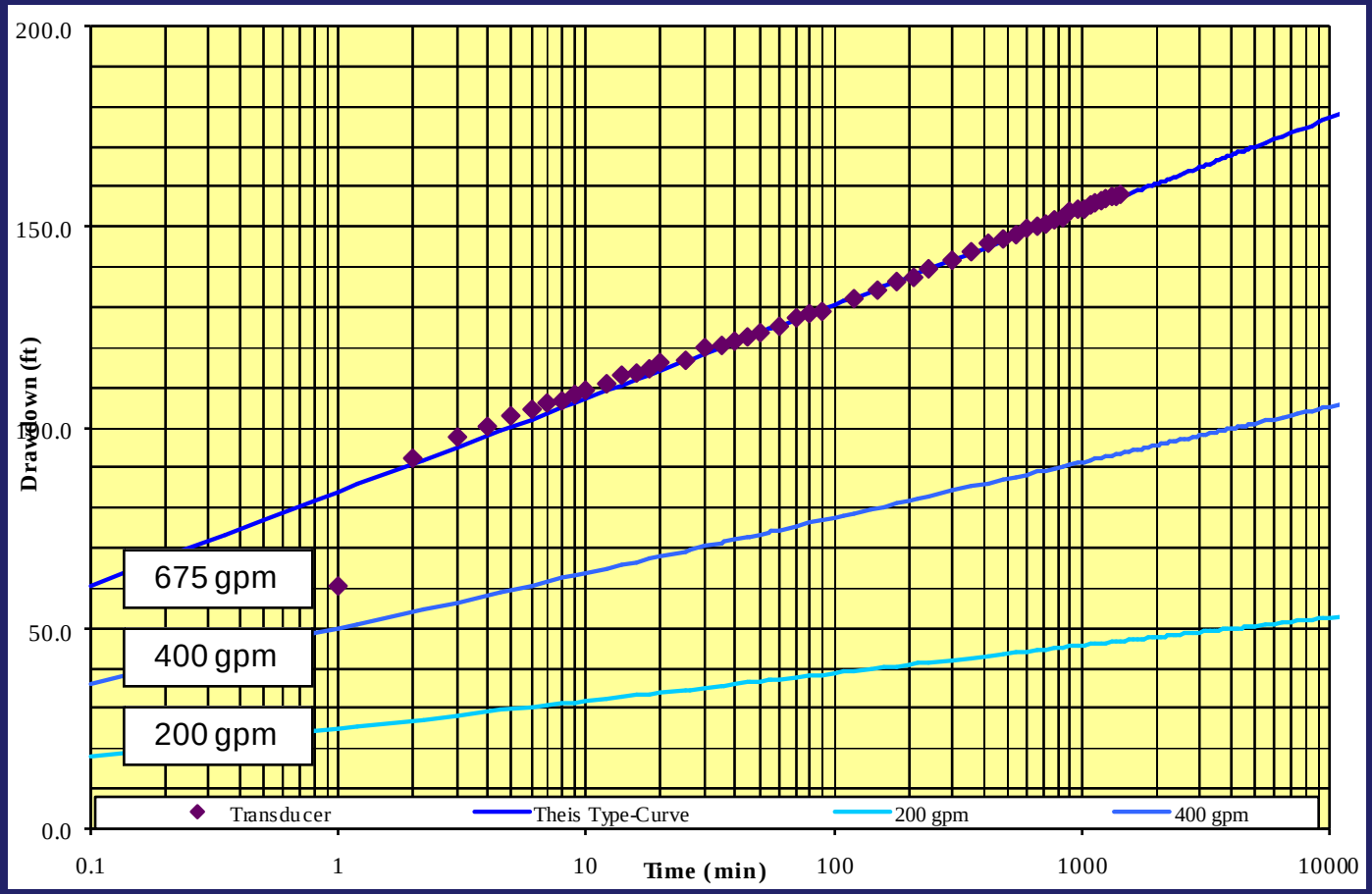
# Well Performance Projections




Same data graphed semi-log

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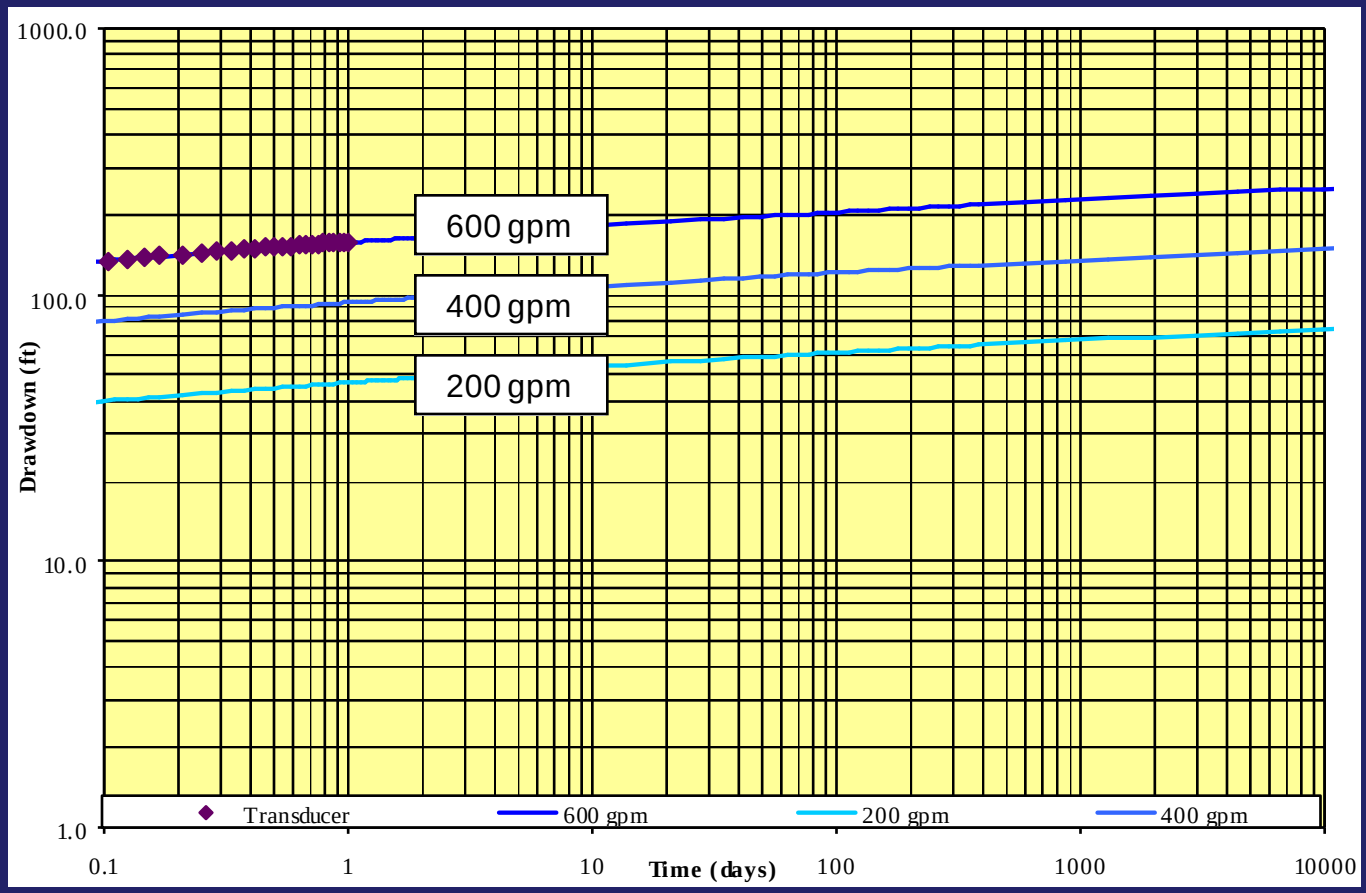
# Well Performance Projections




Estimate drawdown for different pumping periods using calculated transmissivity and storativity

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# Specific Capacity

*Simple Measure of Well Efficiency*

- (Pumping Rate) / (Drawdown) = 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 Q/s at same time after pumping begins
  - E.g. Q/s at 4 hours
  - E.g. Q/s at 12 hours

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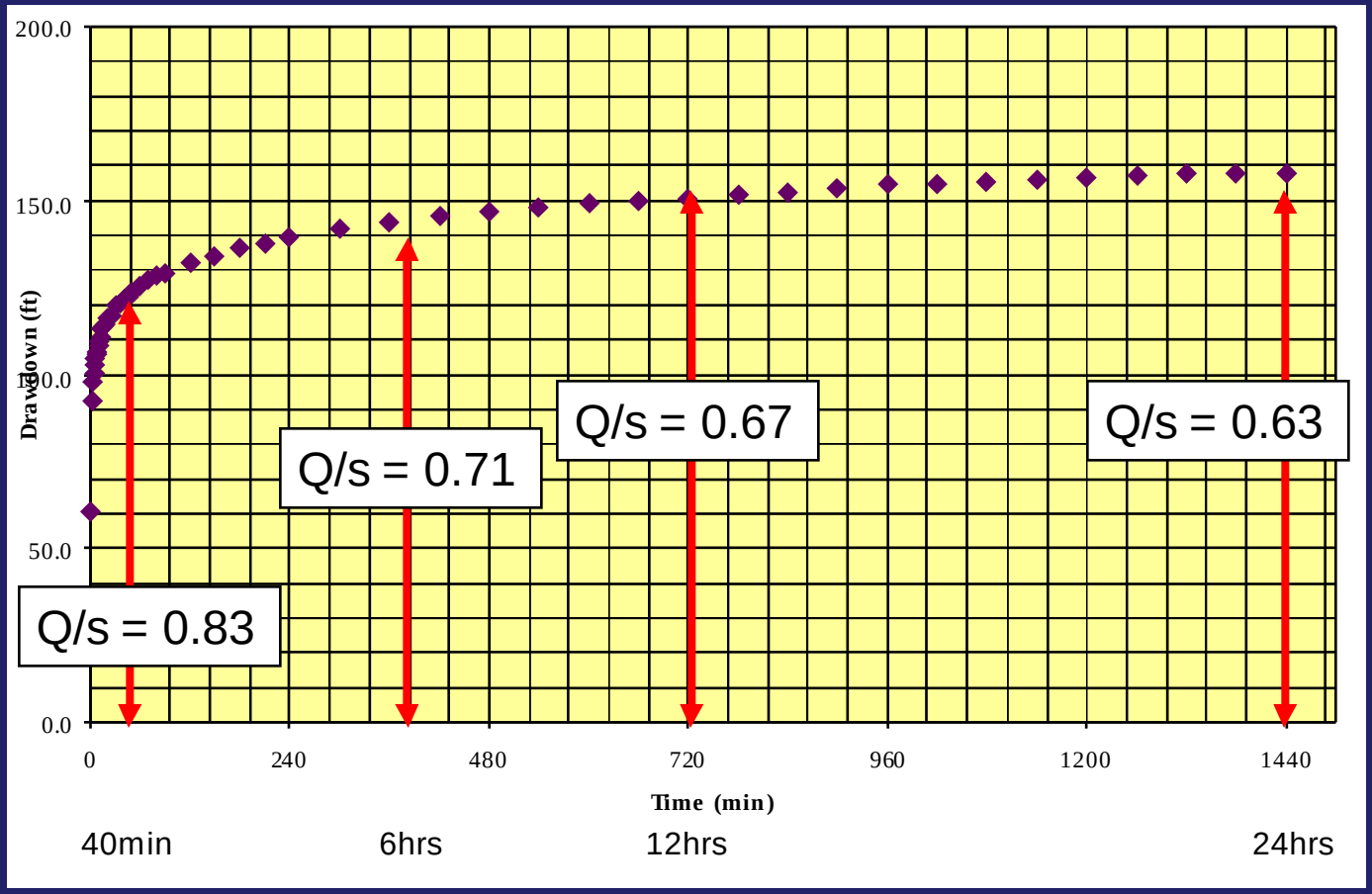
# Specific Capacity




Pumping Rate = 100 gpm

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# Specific Capacity

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

  Then, how much drawdown at 5 gpm after 4 hours?

  (5 gpm) / (0.15 gpm/ft) = 33 ft drawdown

  Say only 70 ft drawdown acceptable?

  (70 ft) x (0.15 gpm/ft) = 10.5 gpm

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# 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

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# 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

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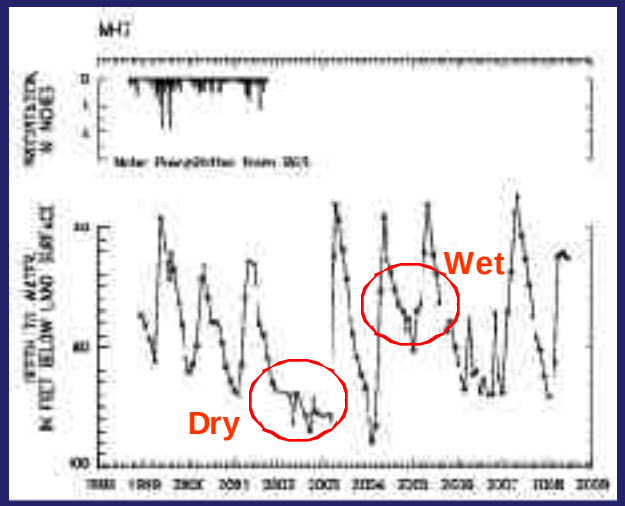
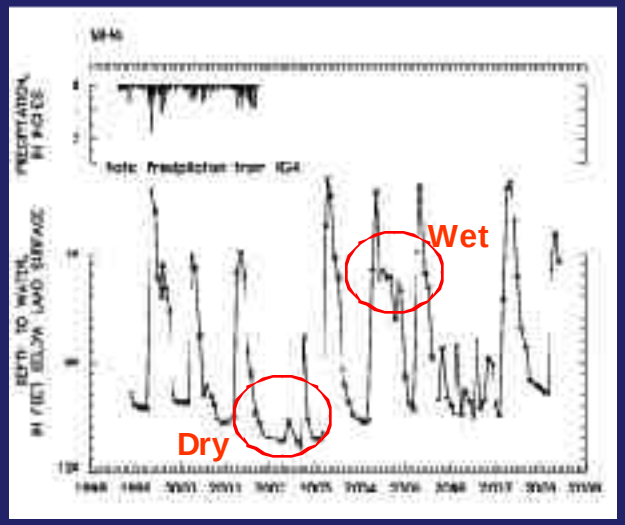
# Jefferson County Mountain Water Well Water Levels




100 ft




120 ft

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

Thanks to Roy Laws

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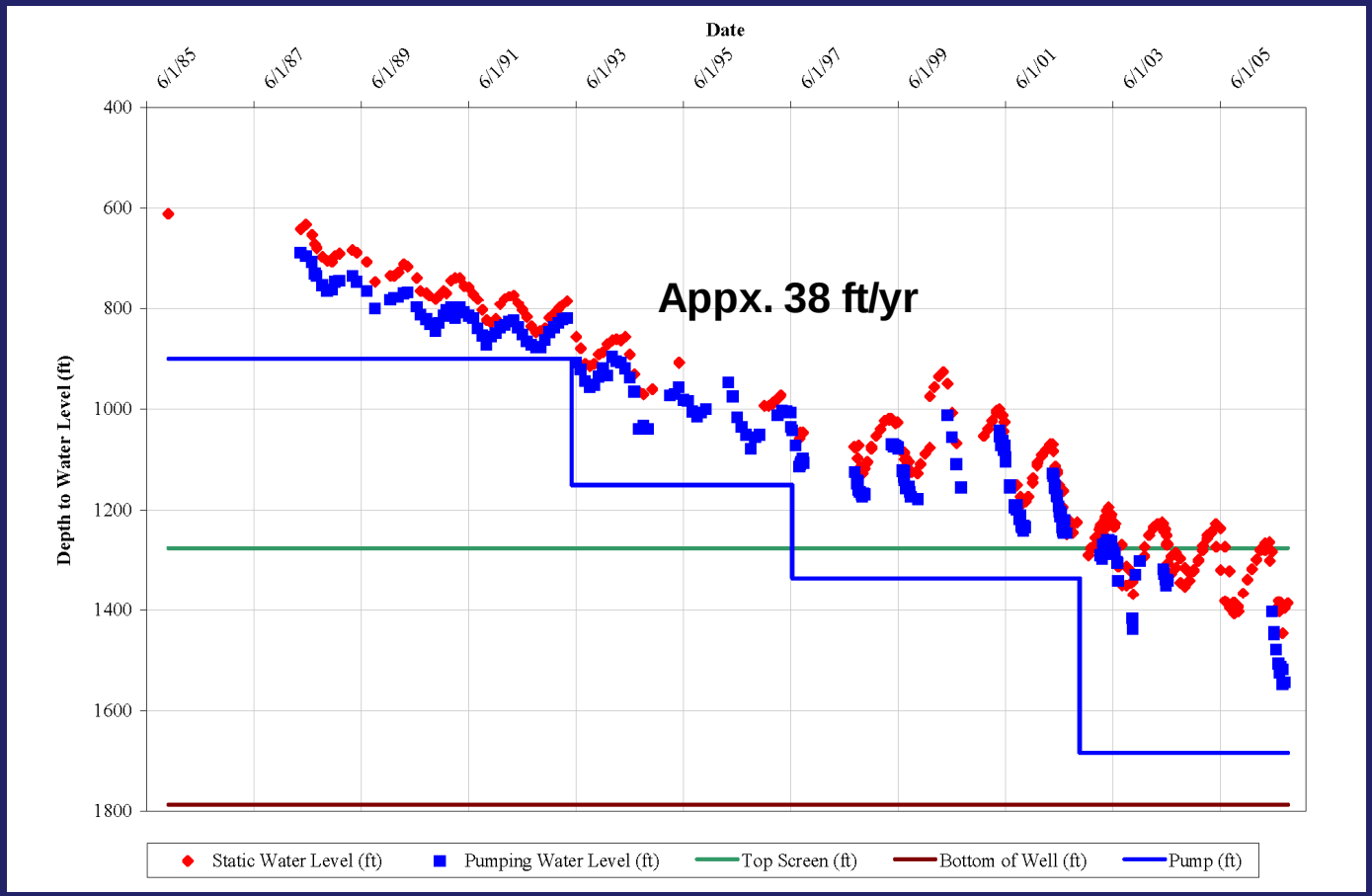
# Denver Basin Water Level Decline

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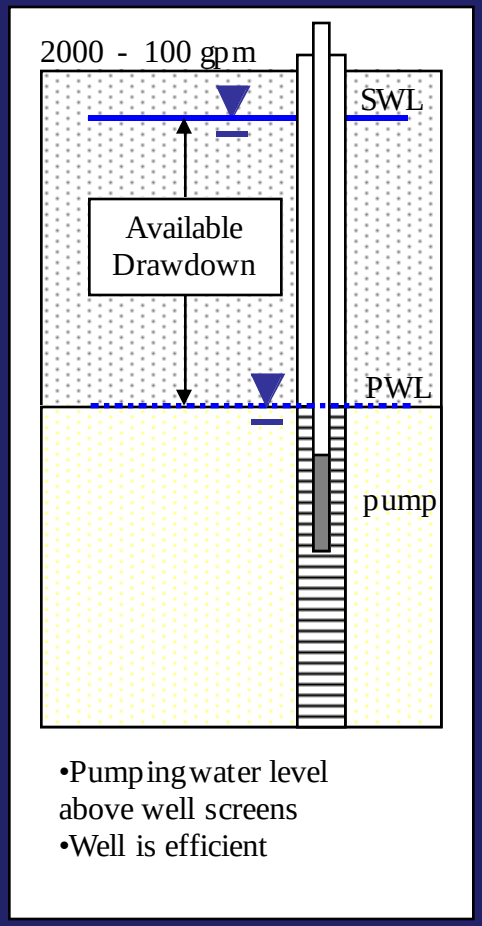
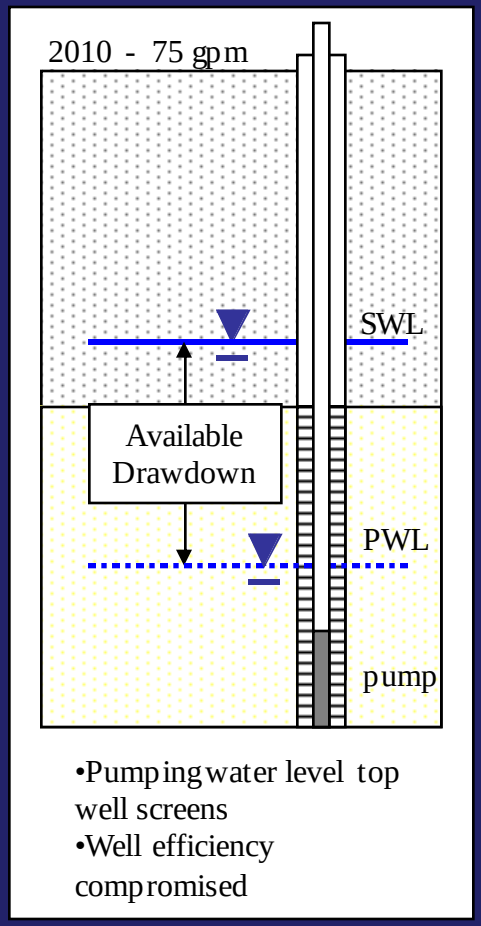
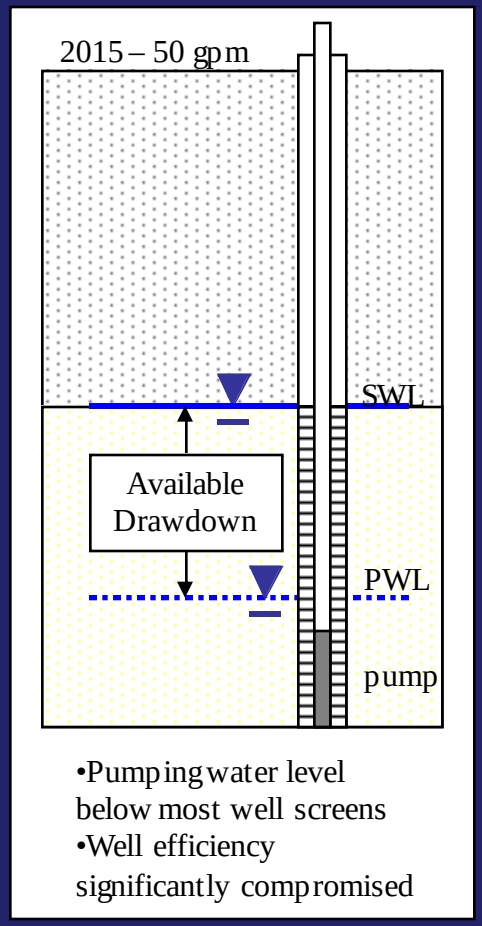
# Declining Denver Basin Water Levels (cont.)




•Pumping water level above well screens
•Well is efficient




•Pumping water level top well screens
•Well efficiency compromised




•Pumping water level below most well screens
•Well efficiency significantly compromised

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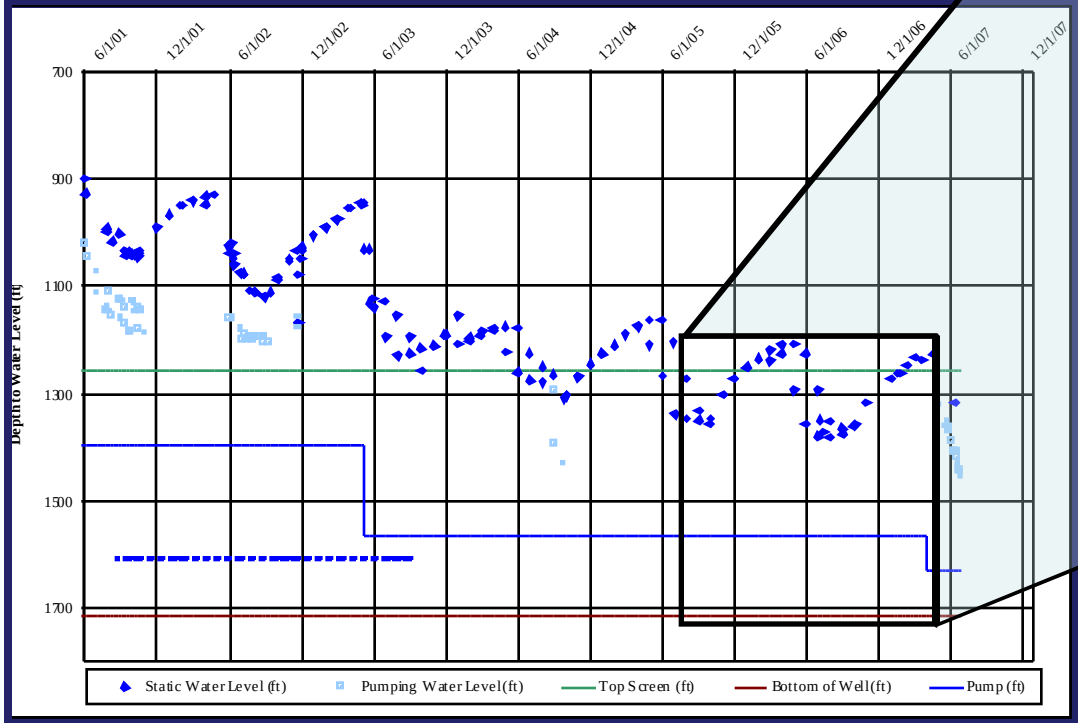
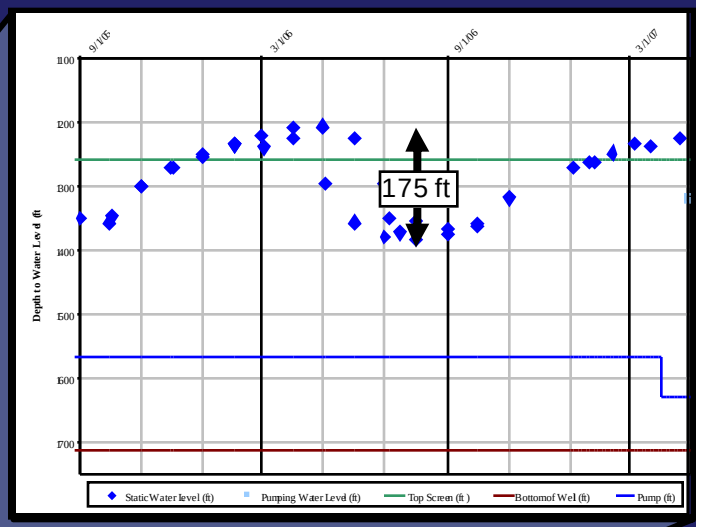
# Confined Aquifer Well-to-Well Interference

- 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

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# 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

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# 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

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