USDA Natural Resources Conservation Service
U.S. DEPARTMENT OF AGRICULTURE

2024 NRCS National Aquifer Testing

FARM PRODUCTION AND CONSERVATION
FSA | NRCS | RMA | Business Center

NRCS has required aquifer testing since 2021

CPS 642 Policy (2021)

Well performance (aquifer) testing
Design the well so at maximum drawdown, the water surface does not drop to the top of the highest screen or pump intake. Wait no less than 24 hrs after well development is completed and the water level has stabilized, to conduct a pumping test for determining specific capacity and dynamic water levels. Refer to NRCS 210-NEH-631 and 210-NEH, Part 650, Chapter 12, Section 650.1205, "Wells" for guidance on conducting, recording, and analyzing pumping tests.

Encouraged to get intimately involved with each assigned conservation practice.

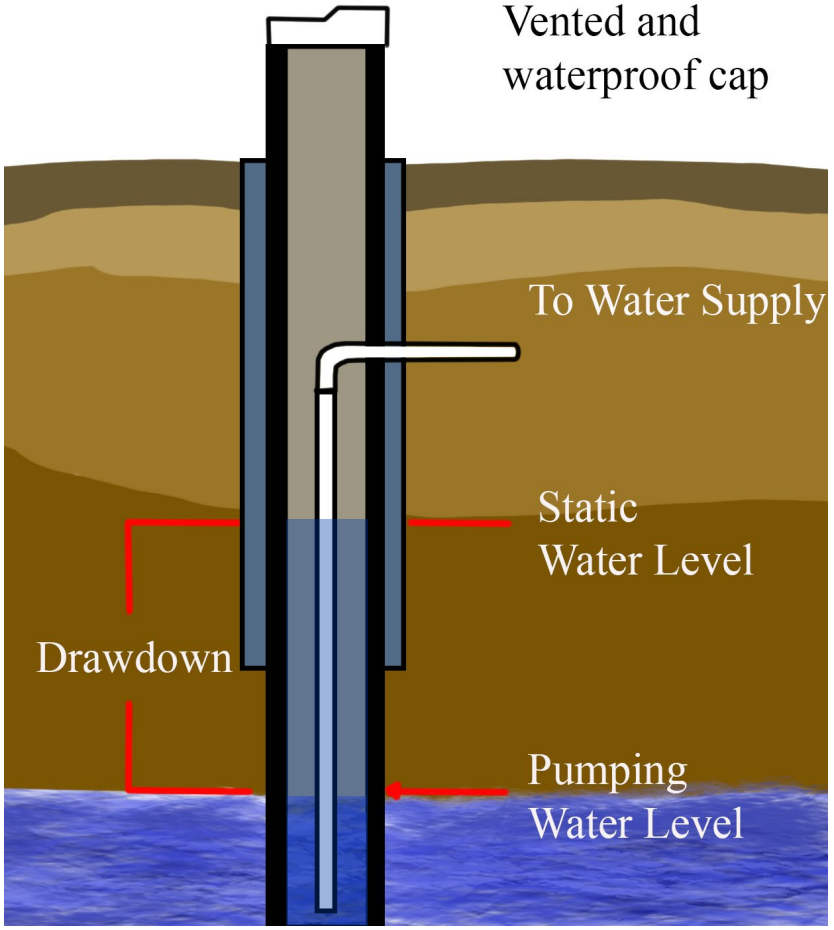
What are Aquifer Tests?

What are Aquifer Tests?

Aquifer Test (ASTM D4043)

- Also called "Pumping Tests", "Drawdown Tests", "Aquifer performance tests", or "Permeability Tests".
- Controlled test, to stress and extract groundwater from a pumping well at a constant rate(s) while measuring the aquifer response (drawdown).
- Drawdown is the difference between the water level before pumping started (static level) and the measured water level in the well after pumping started.

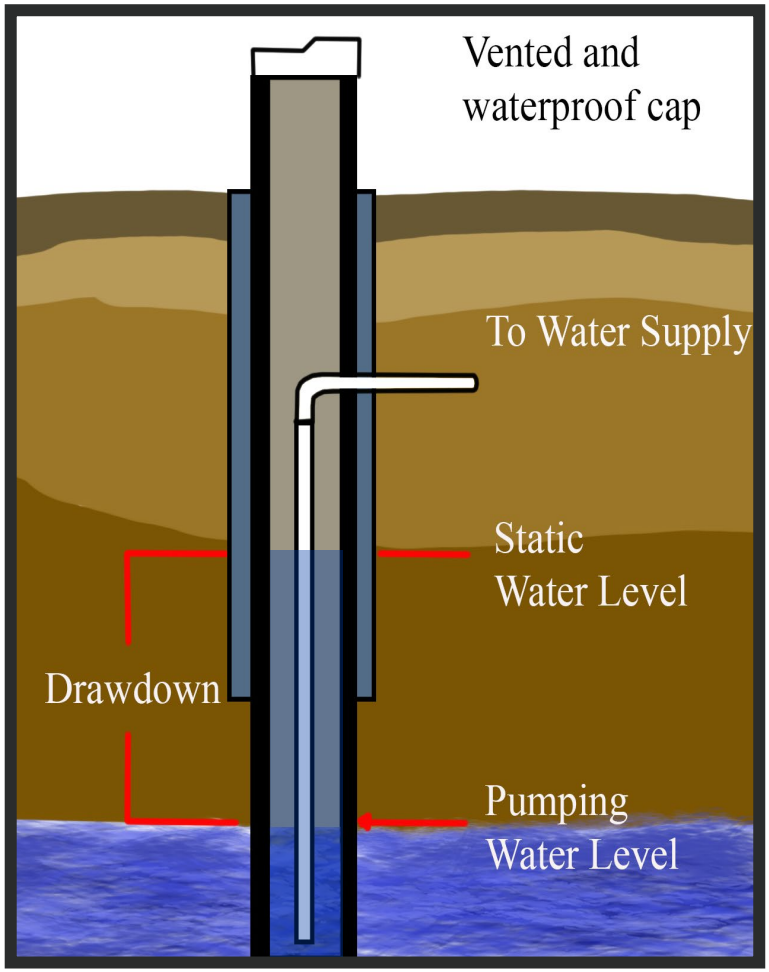
Single Well Aquifer Test



Pumping Water Level	60 ft.
Static Water Level	-15 ft.
Drawdown	45 ft.

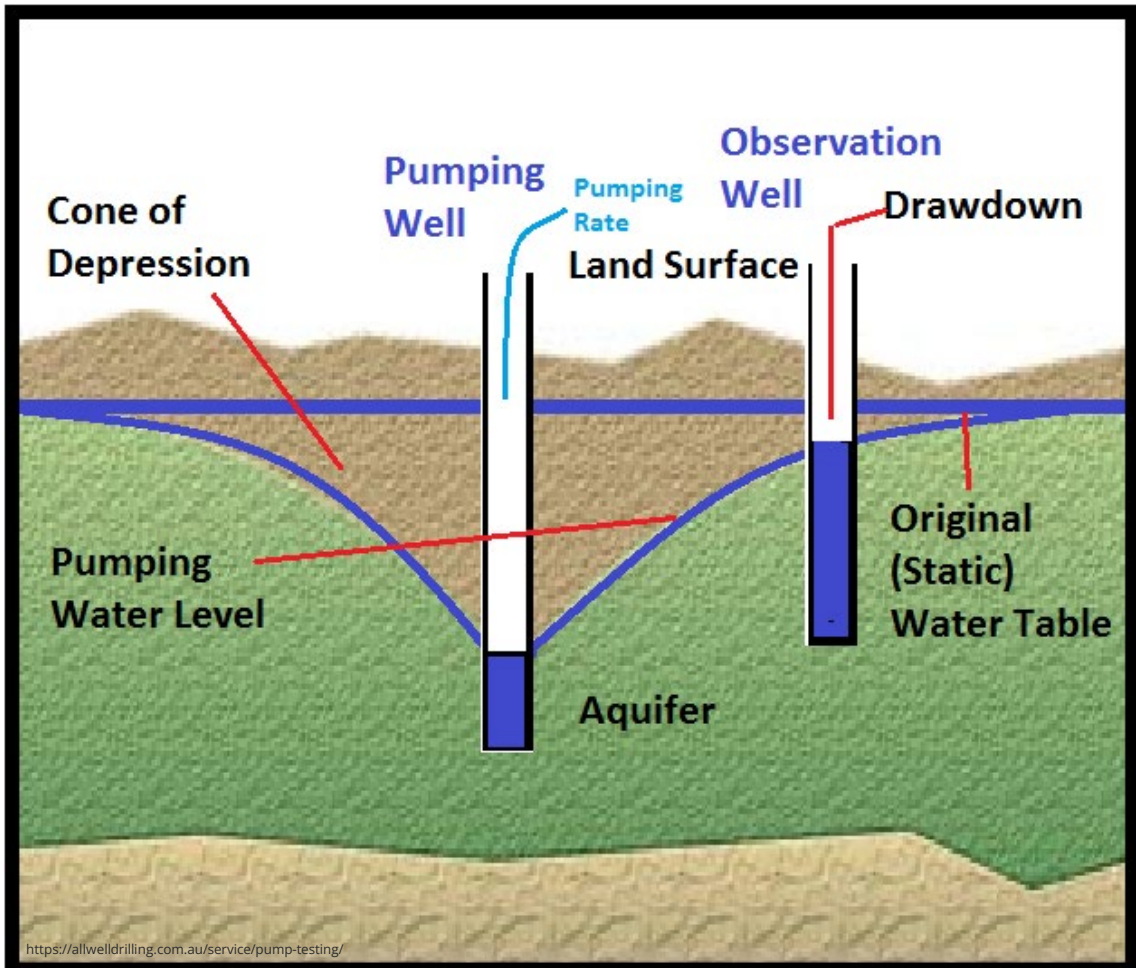
Common Aquifer Tests

Single Well Aquifer Test



NRCS Preferred Test

Multiple Well Aquifer Test

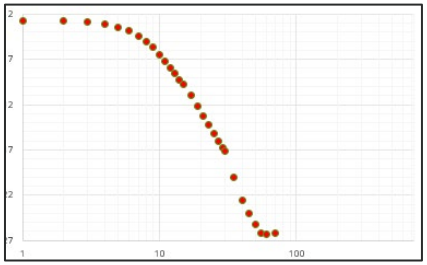


Not practical for NRCS applications

Common Aquifer Tests

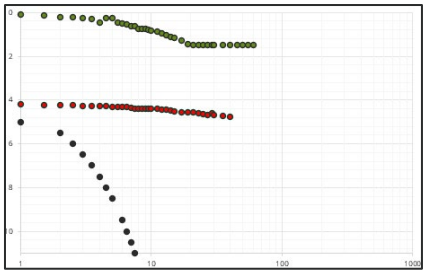
Constant Discharge Rate Test

Pump the well at a constant rate for a specified amount of time, e.g., 4 – 72 hours



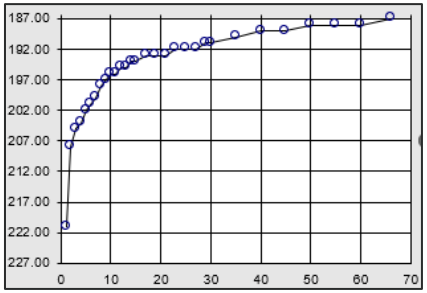
Step Drawdown Test

Pump the well in a series of constant rate steps, each step at a different pumping or discharge rate, with the rate increasing with each step.



Recovery Test

Conducted at the end of an aquifer test, where residual drawdown is measured. Interpreted separately from an aquifer test.



Artesian Flow Test

Without a pump, measure discharge and pressure (psi). Take at least three measurements. With a pump, conducted the same as non-flowing wells.

Why does Montana Prefer a Step Drawdown Test?

- Prevent from returning to the well each time the design flow rate changes between planning and final design.
- Consists of three (3) or more constant rate tests to further stress and collect more aquifer information.
- Determine optimum pumping rate.
- May determine the maximum pumping rate.
- Correctly size the pump (step drawdown test is the most reliable method for determining a pump size).
- Evaluate the potential for long-term reliability.
- Evaluate well performance (efficiency) and relative success for well development and/or rehabilitation.
- Easy to conduct and offers detailed information.

What are Aquifer Tests?

Aquifer Tests are Not Pump Tests

- **American National Standards Institute (ANSI)/HI11.6 and ANSI/HI14.6**

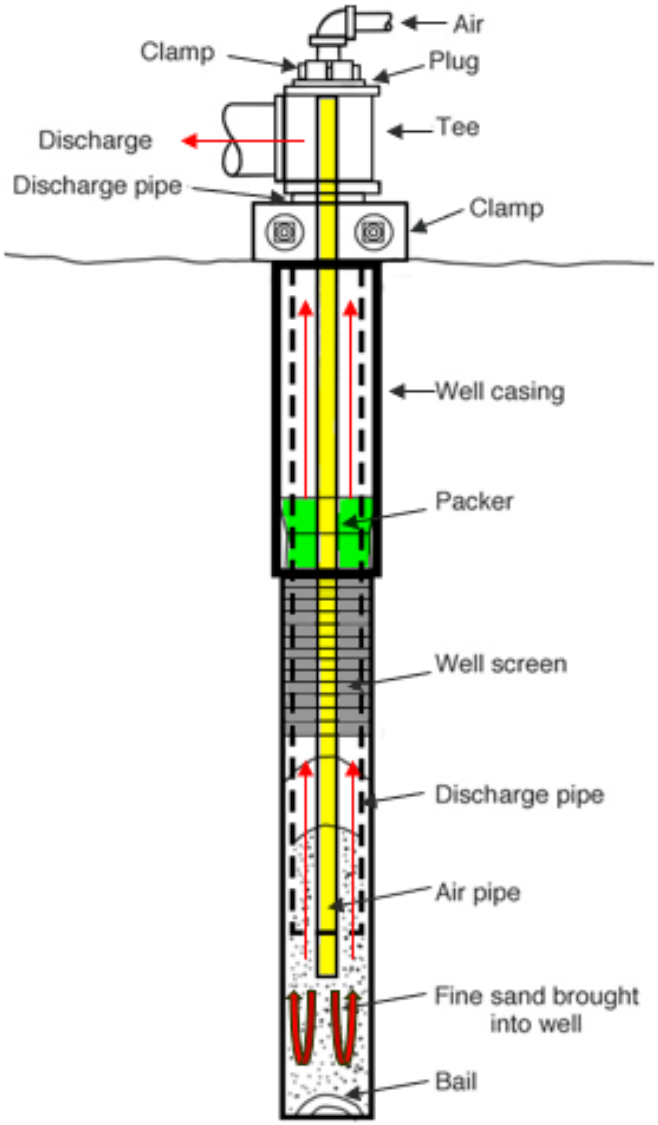
  - Pump tests evaluate the pump and motor efficiency, energy use, and has nothing to do with the well or aquifer.

  - Pump manufacturer, supplier, or installer conduct this test.

What are Aquifer Tests?

Aquifer Tests are Not Air Tests

- Also called “Airlift”, “Well Development”, “Well Yield”, “Well Test”.
- Air tests are important (!) well development procedures to increase production rates and can extend the well life after construction.
- Air “tests” are not a reliable method for estimating yield due to turbulence caused by air injection, variable injection pressures, and adding entrained air/water. These methods may cause considerable error in measuring the flow rate.
- Generally, pumps water locally around the well
- Air “tests” are **not** aquifer tests and are **not** a substitute for aquifer tests.



Reference based on: https://openjicareport.jica.go.jp/pdf/11836988_08.pdf

Air Test vs. Aquifer Test

Well	Air Test	Aquifer Test	% Less	Well	Air Test	Aquifer Test	% Less
219005	150 gpm	135 gpm	10%	**223447**	24 gpm	11 gpm	54%
230579	12 gpm	10 gpm	17%	**277053**	200 gpm	30 gpm	85%
263051	25 gpm	12 gpm	52%	**235364**	80 gpm	24 gpm	70%
199181	90 gpm	48 gpm	47%	**243916**	15 gpm	10 gpm	33%
294703	5 gpm	1.5 gpm	70%	**282410**	80 gpm	70 gpm	13%
295939	40 gpm	20 gpm	50%	**250412**	40 gpm	15 gpm	63%
264837	50 gpm	35 gpm	30%	**258405**	40 gpm	15 gpm	63%
281617	16 gpm	8 gpm	50%	**264350**	40 gpm	25 gpm	38%
249004	12 gpm	10 gpm	17%	**192751**	25 gpm	17 gpm	35%
238588	30 gpm	18 gpm	40%	**271249**	30 gpm	12 gpm	60%

Air "Test" is based on turbulent, changing conditions due to the variation of pumping rate and pressures used.

Aquifer test is based on actual testing and measurements under controlled conditions.

Information collected from some Montana water well logs

Note: Aquifer testing is typically much lower than air testing.

Scenario: (~2016/2017 MT Aquifer Test)

- Contract drilling company drilled and conducted an aquifer test. The driller said they were confident the well produced 7 gpm. They conducted a step drawdown test, 2, 5, and 7 gpm planned pumping rates.

- What Happened

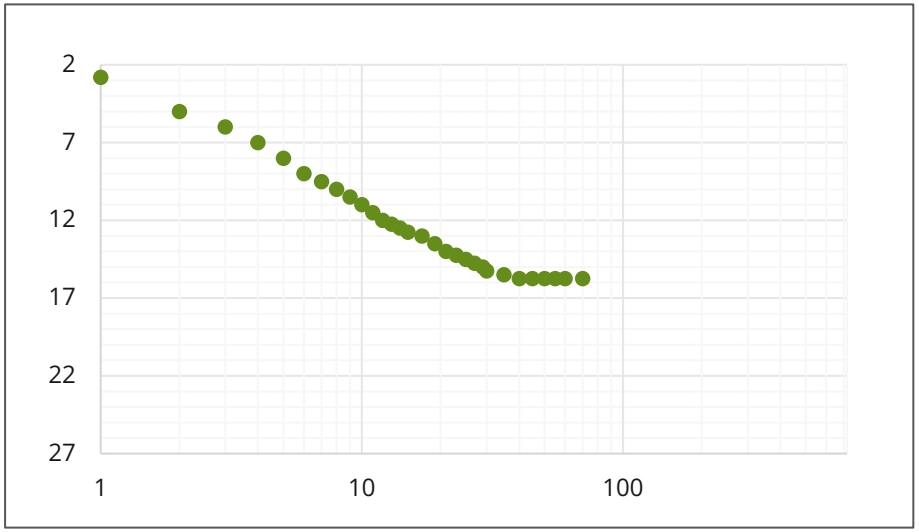
  Water levels showed steady drawdown at 2 gpm and water levels quickly drew down to the pump take at 5 gpm. After pumping stopped and the recovery test began, water levels took 3 days to recover back to static. Driller was surprised at the test results and saw meaning for the tests.

- What Does this Mean?

  The aquifer test showed the well could barely produce < 1 gpm. This is 86% less than what the drilling company estimated. The recovery test showed recharge was limited and slow and this well has questionable reliability. NRCS decided to work with what this well could produce, keeping the pumping rate around 0.5 gpm.

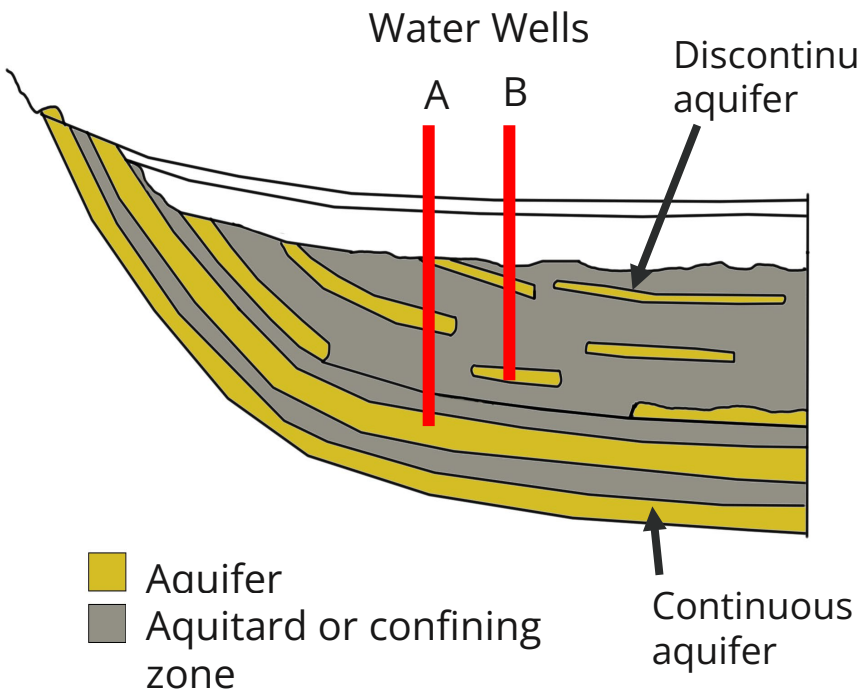
Drillers are not conducting aquifer tests if:

1) Pumping rate and pressures are not controlled
2) Developing the well
3) Drawing water levels to the pump intake and recording it as well yield on the log.
    - Maximum yield is the maximum amount a well is pumped without experiencing additional drawdown.
4) Frequent drawdown data and time are not collected
5) Frequent residual drawdown (water recovery) data and time are not collected



Why Conduct Aquifer Tests?

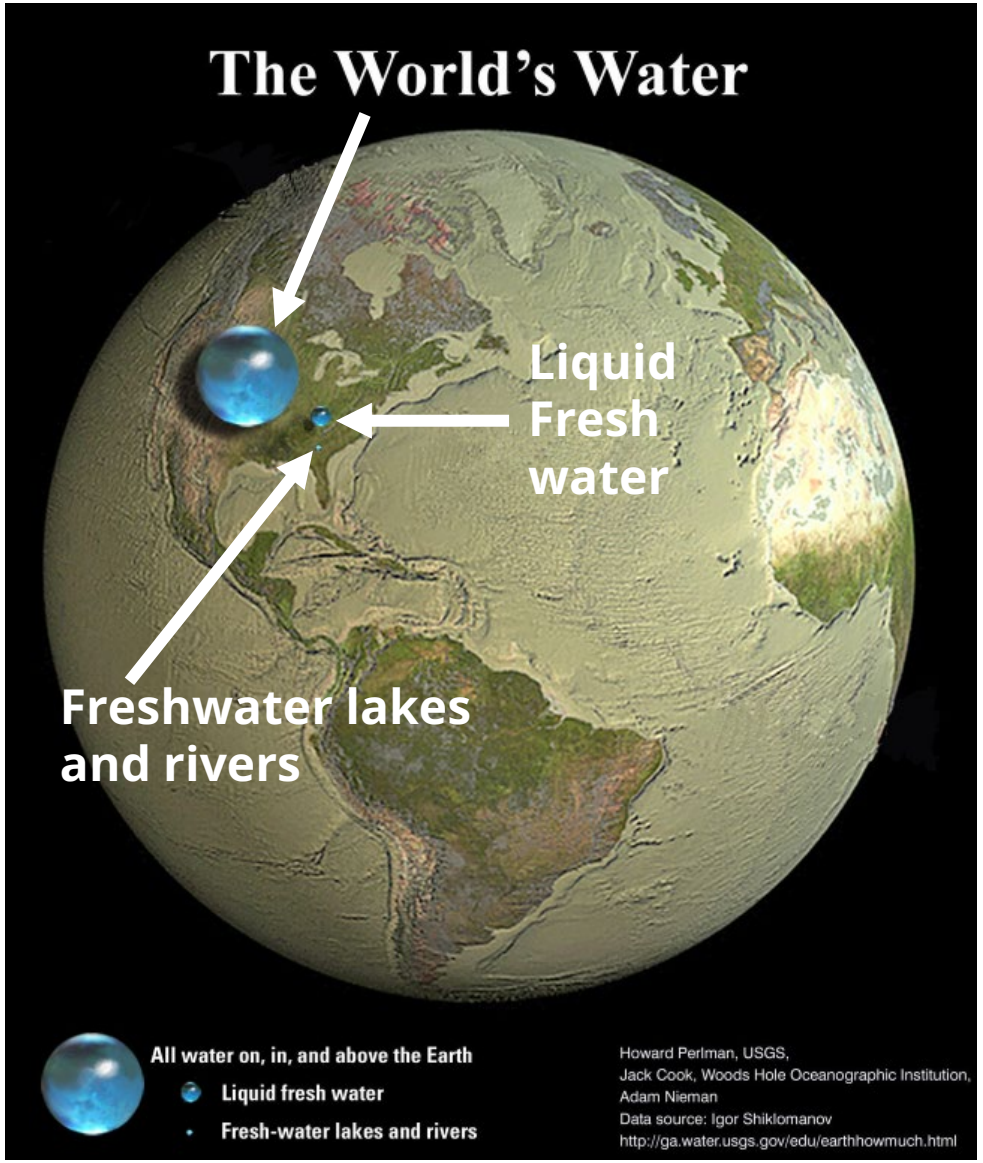
- Improve accuracy of yield estimates (greater confidence).
- Collect drawdown data to evaluate sustainability at the planned flow rate.
- Determine suitable pump depth and the total dynamic head (TDH = Elevation head + friction loss + pressure head).
- Evaluate water levels at startup and between pump cycles to determine if pressure relief or a variable frequency drive is needed to protect the remainder of the system.
- Well log information is absent, incomplete, or dated.
- Locate unforeseen factors (e.g., boundaries, fractures, recharge, etc.).



- Complex geology, can consist of discontinuous, thin aquifers that limit production rates and yield sustainability.

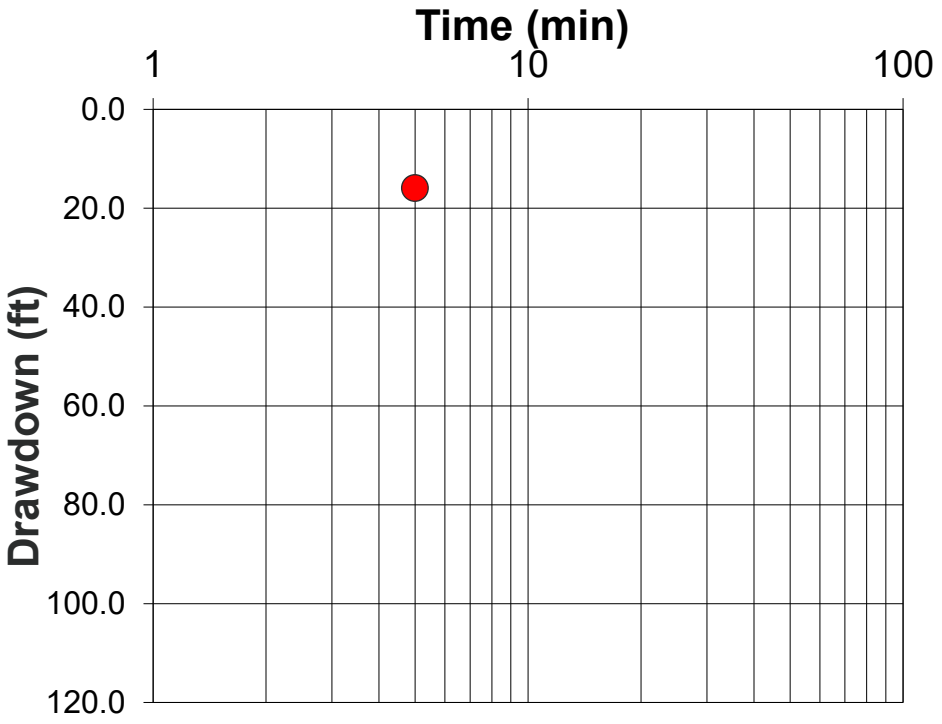
Why Conduct Aquifer Tests?

- Climate Change
- Aquifer depletion
- Can help farmers and ranches maintain a water source
- State Law may require aquifer testing.
- **Promotes Conservation**
  Prevents overextraction, take only what you need, and prevents adversely impacting aquifers.



All of Earth's water in a single sphere! | U.S. Geological Survey (usgs.gov)

What Information Can One Point Offer?



One questionable air tested point

Are there hydraulic barriers or recharge zones that can impact the yield or sustainability?

What is the well performance?

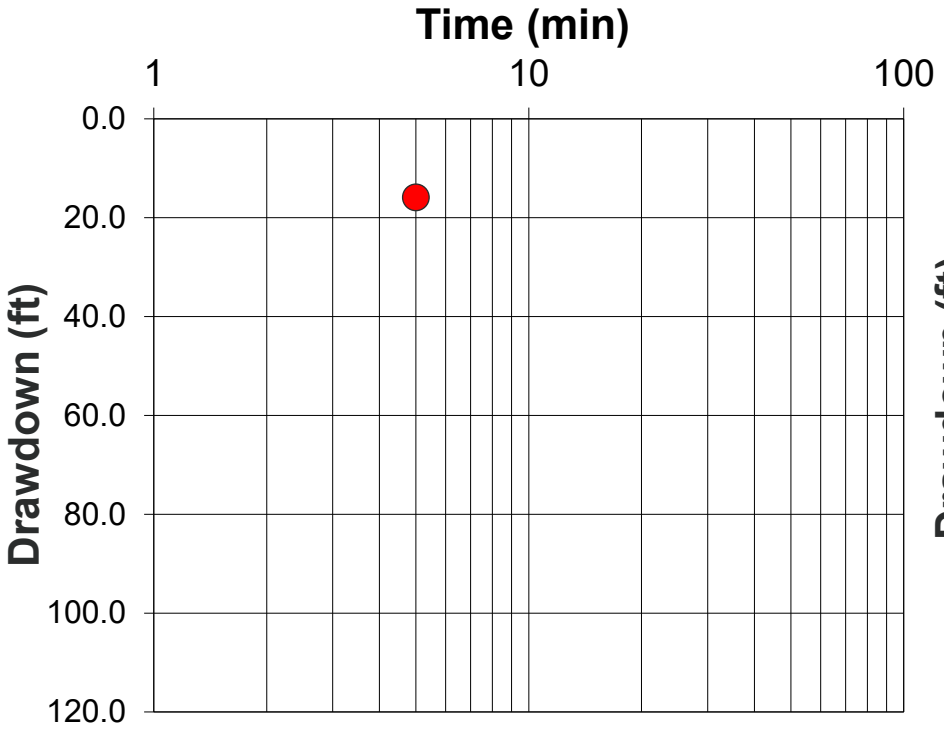
What is the water level between pumping cycles?

How much drawdown occurred?

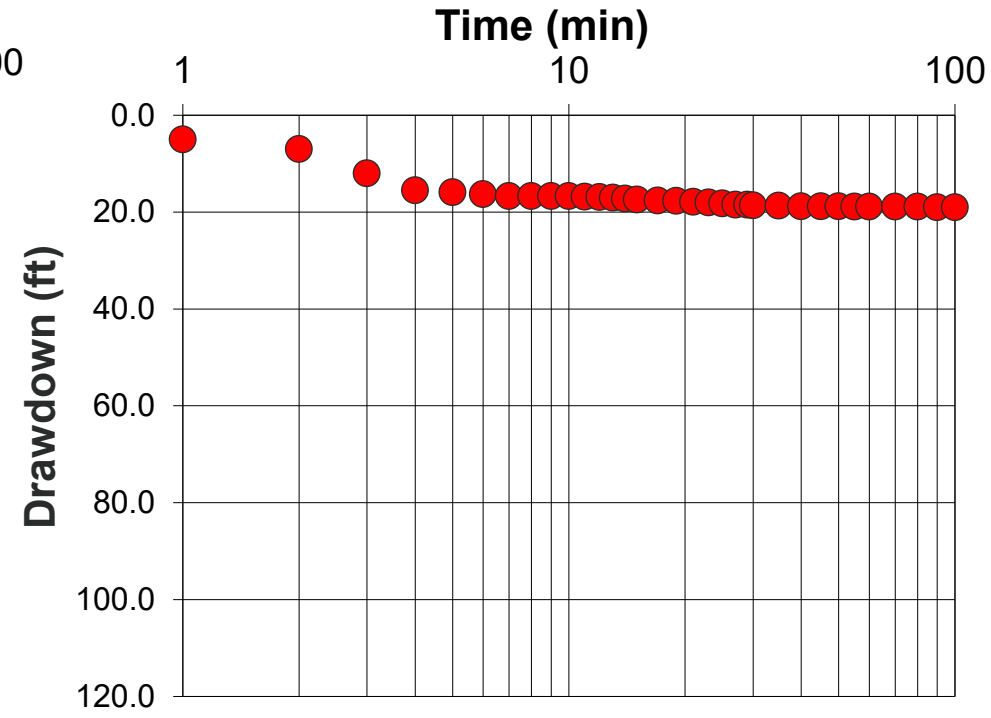
What is the projected drawdown for a specific operating time?

Answer: One data point that is often a pumping water level measurement (not drawdown) does not give enough information to answer these questions.

Which Graph Gives the Better Information?

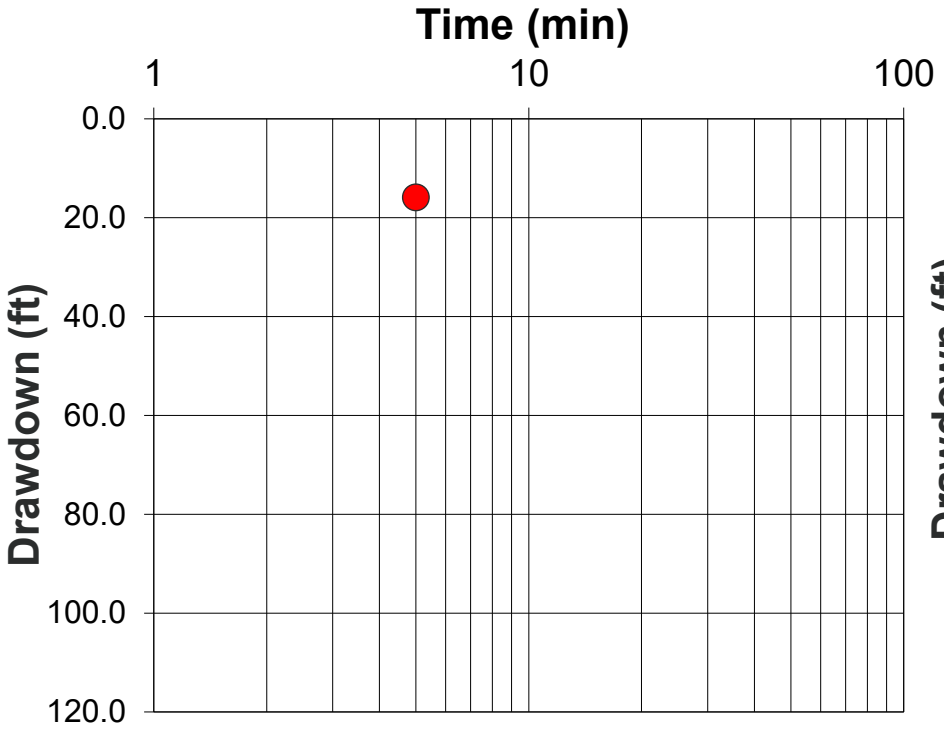


One questionable air tested point

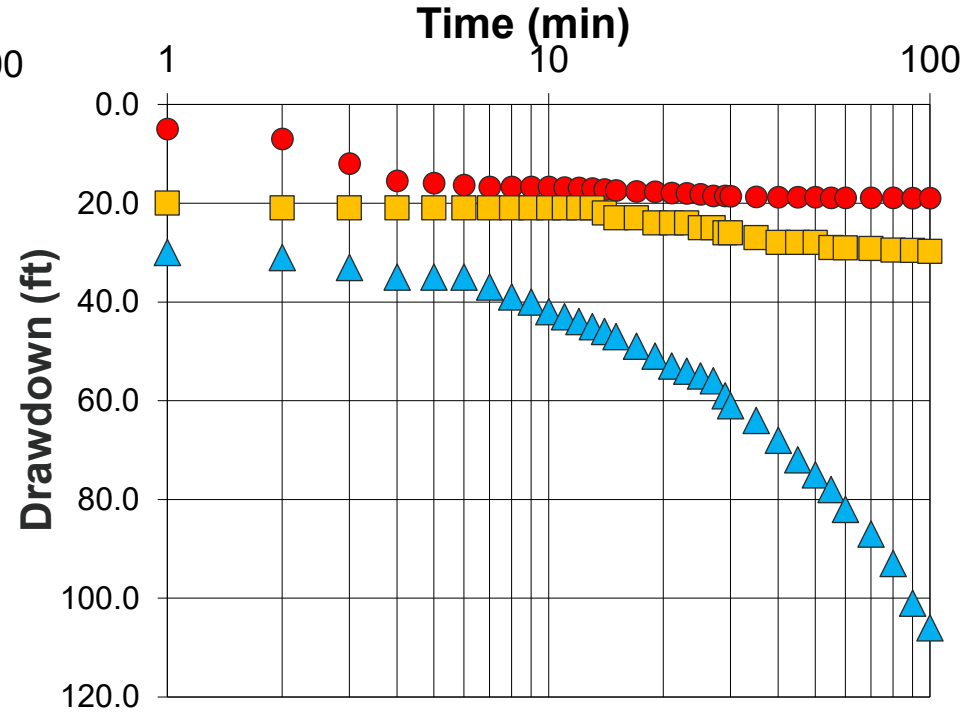


Many, better estimated points.
The more points the better.

Which Graph Gives the Better Information?



One questionable air tested point



Many, better estimated points at different pumping rates.

What Happens if We Don't Conduct an Aquifer Test?

What if We Don't Aquifer Test?

- Consequences for over-pumping the well:
- For stockwater, cattle loiter around the tanks or work a tight circle.
- Less water is delivered to the system, but the flow reduction may not be obvious (e.g., spit air).
- Overheat submersible pump motor (insufficient cooling flow).
- Pump would run continuously, trying to seek a sufficient volume of water to fill tanks. This will cost the producer more money.

- Consequences for selecting a pump that is too large:
- Initial cost - high and unnecessary.
- Overheat submersible pump motor (rapid cycling, re-circulating) .
- Water hammer damage due to high flow and rapid shutoff.
- Inadequate pipeline pressure class.
- Pressure relief valve discharge on startup.

Scenario 1: (Prior to MT Mandating Testing)

- NRCS constructed a livestock pipeline system without aquifer testing the water supply well. The well failed 24 hours after turning on the pump and the new livestock pipeline rendered not useable because a water source was not available.

- What Happened

  The well pumped dry because of a limited aquifer source.

- Lessons Learned:

  Aquifer testing would have shown the well was not suitable for use and NRCS could have planned accordingly. Plans may have included aquifer testing the house well to evaluate if the well could handle the stress from the added production rate for the planned system. Alternatively, drilling a new water well at a different location.

Scenario 2: (Prior to MT Mandating Testing)

- A driller completed a new 160-foot-deep well in central Montana, the well air tested 4 gpm. Six years later the well pumped dry. NRCS conducted a video-inspection and found no casing defects and static water level was 53.8 feet below ground surface.

- What happened

  Discharge (too high of pumping rate) exceeded recharge (slow recharge). Water levels did not have a chance to return to static between pumping cycles. The well over pumped. The pump continuously ran looking for a water source and burned out.

- Lessons Learned:

  Aquifer testing would have identified this well could not pump 4 gpm and had slow recovery. NRCS could have planned accordingly, including lowering the pumping rate.

Scenario 3: (Prior to MT Mandating Testing)

- A driller completed a new 2,060-foot-deep well into a confined aquifer. The well log shows the drill stem is set at 830 feet and the driller air "tested" 40 gpm. Design flow rate is 5 gpm. NRCS engineer is responsible for specifying pump Total Dynamic Head (TDH). What TDH value is appropriate?

- Answer:

  Nobody knows…

QUESTIONS?

If you have questions in the future about aquifer testing, contact your NRCS State Geologist or Susan Grover, NRCS National Geologist at susan.grover@usda.gov.