Virginia Department of Health -
Well Yield and Drawdown Pump Test Procedures

These procedures are designed specifically for wells located outside of one of the Coastal Plain Groundwater Management Areas and when a DEQ Aquifer Test is not required.

Virginia Department of Heath Office of Drinking Water
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VDH VIRGINIA DEPARTMENT OF HEALTH

Office of Drinking Water
Safe Drinking Water for a Healthy Virginia

Introduction

This document describes the procedures established by the Virginia Department of Health that apply to wells located outside the Coastal Plain Groundwater Management Areas and that are not subject to the Department of Environmental Quality Aquifer Tests.

The standard yield test lasts for a duration of at least 48 hours. However, the Office of Drinking Water may approve a reduced test duration for noncommunity water systems.

- Community water systems serve 25 or more people, or a total of 15 or more connections, for more than six months of the year.
- Non-transient non-community water systems serve 25 or more of the same people for 60 days or more a year.
- Transient non-community water systems serve 25 or more different people for 60 days or more in a year.

These pumping tests are completed to ensure that enough water is available to provide the system's needs, while at the same time not negatively impacting the groundwater water supply or other existing wells. This means that, while providing enough water for the system, the aquifer is not depleted by pumping more water out of the well than is flowing into it. There is also a requirement to test other wells at the same time, if they are within 500 feet of the well being tested. This testing ensures that the well can provide enough water for the system without depleting the amount of water in the neighbor's well. It is a good idea, but not a requirement, to monitor the static water level of other close wells that are more than 500 feet away from the well being tested. This option may help provide information regarding the effect of pumping the new well. Groundwater at a well may have a constant flow rate and achieve a stabilized pumping water level. However, a neighboring well may have a decreasing water level. You need to determine a constant flow rate where a stabilized pumping water level is achieved, and other monitored wells have a stabilized non-pumping water level.

Step 1: Initial Estimate

The well driller will usually estimate the well flow rate after completion of a drilled well. (See Appendix 1 for suggested methods.)

The estimated pump rate helps with the selection of a pump large enough to pump the maximum volume of groundwater without lowering the water level below the minimum submergence required for the pump (exhaustive capacity). Sometimes the estimated well yield is much larger than a pump can provide because a small diameter well limits the flow into the pump. In this case, utilize the largest pump (greatest pumping capacity) that will fit in the well. The size of the piping, wiring, and generator should also be selected to match the flow rate expected from the selected pump. Otherwise, the flow rate may be limited by the size of pipe connected to the pump, the wiring may be of insufficient size for the pump to function at full capacity, or the generator may not produce sufficient electricity to power the pump at full capacity.

The well yield may be far greater than the yield necessary for your needs. If this is the case, you may choose a pump which can produce your needs and perhaps a little more as a safety factor.

This will also allow the well to stabilize more quickly since it is not being as stressed. For example, if your system requires 5 gallons per minute, but the well has the potential to produce 30 gallons per minute, then there is no need to demonstrate a yield of more than 8 gallons per minute.

Note: The pump test will have more value if the whole test can be completed at a constant pump rate. To achieve this, it is helpful to pump the well for an hour or two several days before you begin the actual 48-hour pump test. This pre-test will function as a step draw-down test, where the sustained pump rate may be determined prior to the day of the pump test. That is, the rate at which the well production matches the pump rate because the water level is no longer falling. Monitoring the water level in a nearby public well or even a private homeowner's well can also add more value to the information gained from the pump test. This added data from the nearby well will allow hydrologists, geologists, or engineers to calculate important features of the aquifer at a later date. Furthermore, these step drawdown tests also allow troubleshooting of proper sizing of pumps, pipes, generators, and wiring. Problems may arise from where you chose to divert the effluent water from the test. A pre-test will help evaluate the best alternatives for discharge.

Step 2: The Well Setup

The pump should be installed with a meter and throttling gate valve in place so that the gallons per minute of flow can be determined by timing the meter with a stopwatch, and the flow can be adjusted by opening and closing the gate valve.

You also need a way to measure the water depth in the well. (See Appendix 2 for suggested methods.)

Step 3: Documentation

Enter the data from the pump test into the Well Yield and Recovery Report. If you obtain a copy of the Excel computer spreadsheet from VDH and enter the data, it will complete the calculations for you. (See Appendix 3 for additional calculations and Appendix 4 for Well Yield and Recovery Report.)

Initially you will be pumping with the gate valve not throttled and will make observations and record data every five minutes for a total of six intervals or thirty minutes. Next you will make observations and record data every 15 minutes for an hour and a half.

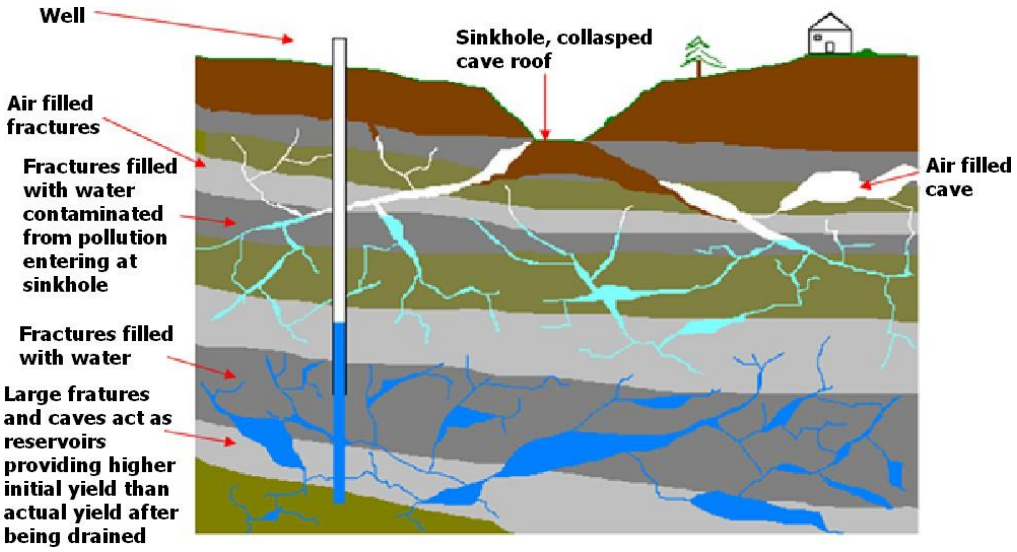
You will then be required to record your observations once every hour. However, you may need to check more often if your water depth is still falling and not stabilized at a constant pump rate, or if you are not yet sure that you have throttled flow to the point that your pump will remain submerged in water.

Note: Make sure you are aware of your pump depth and begin to throttle your flow down (by partially closing the gate valve a little at a time) to keep the pump submerged in water.

Continue to throttle the flow back with the gate valve until depth to water remains unchanged. It is possible to throttle too much and observe a decrease in the depth to water as the water level begins to rise. In this case you would open the throttling valve to increase flow from the pump to find the pump rate at which the depth to water does not change. Once you have found this pump rate you should not need to make any more adjustments to the throttling valve. A constant pump rate which does not cause the depth to the water to change is required for the final six hours of the pump test. If you do not reach this rate until the last hour of the pump test (48th, 24th or 8th), you will need to pump for another six hours. Remember, if you have already exceeded the flow that you need, you can throttle down and stabilize the well sooner.

Note: Some wells will be muddy or turbid at the highest pump rate that produces a stabilized water level but may be clear at a lower pumping rate. In other words, the well will reach a stabilized water level at a constant pumping rate but remain muddy. When the pump rate is decreased, the water will be clear. This should be noted on the report. The yield will be the lower pump rate at which the well is not muddy or turbid. It is always possible to pump the well longer than the required 48 hours at the maximum rate to see if it clears up.

Note: In some rock aquifers you may find two or three periods of stabilized flow rates and water levels that persist for a period of time and then begin to drop again. This can happen due to interconnected fractures or caverns acting as reservoirs that can supply water at a higher flow rate until drained. (See figure below) Once a void is drained you will again have to find the flow rate of water recharging the well. Several different fracture series full of water may be encountered when drilling a well and may have to be drained before you can find the true stabilized well yield. This is usually indicated by at least six hours of constant flow rate and a stabilized pumping water level.



Step 4: Bacteriological Sampling

Collect one bacteriologic water sample per hour for the last twenty hours of a forty-eight-hour drawdown test. Twenty samples are required to be analyzed utilizing the "Most Probable Number (MPN)" method. They will be collected one per thirty minutes for the last ten hours if you are conducting a twenty-four-hour drawdown test. If you are conducting an twelve-hour drawdown test for a noncommunity water system with design capacity need of less than 3 gallons per minute, you will need to collect samples every thirty minutes over the last ten hours.

(Twelve-hour pumping tests are only allowed if the noncommunity water system has a source water requirement of three gallons per minute or less over normal hours of operation. In these instances, the purpose is to prove that you can reliably pump for twelve hours at or above the needed pumping capacity without depleting the aquifer. If the noncommunity water system has capacity needs of greater than three gallons per minute, it must complete a 48-hour pumping test.)

Step 5: Water Quality Sampling

Chemical samples required during these pump tests should be collected during the last thirty minutes of the test. Contact the Virginia Department of Health, Office of Drinking Water for a list of samples required during the pump test.

Step 6: Recovery Test

After completing the pump test for the designated time with a minimum of six hours of constant flow rate and stabilized pumping water level, you will need to complete the Well Recovery chart. For this procedure you will monitor the well for another six hours without pumping. Note the change in depth to water every thirty minutes for six hours, or until the depth to water recovers to the level observed at the start of the pump test. After six hours, even if the water level has not recovered to the pre-pump test level, you are done. This information is helpful in determining the effect pumping this well has on the aquifer and therefore long-term sustainability of this well.

APPENDIX 1

TECHNIQUES TO ESTIMATE WELL FLOW RATE

One way to estimate well flow rate is by pumping compressed air through the drill bit into the hole while the drill bit is spinning to create an air lift pump. This will cause water to flow out of the hole which can then be diverted by a mud weir or a ditch to flow into a five-gallon bucket (or larger container of known volume when required, e.g. 55-gallon barrel or 1,000-gallon tank) and be timed with a stopwatch.

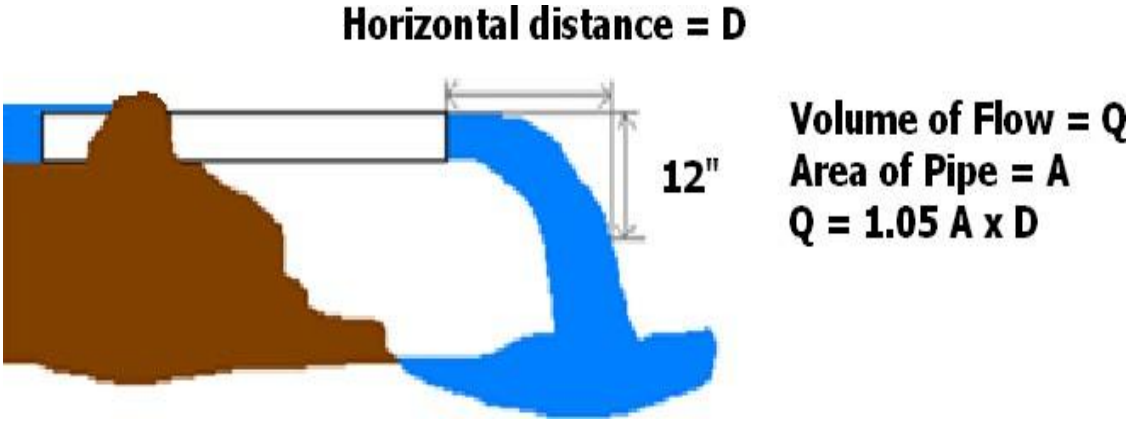
Well Flow in gal/min = (5 gals in bucket) x (60 sec/min) ÷ __ sec to fill bucket

Another method employed by some drillers is to use an air lift pump as mentioned above, but to divert water exiting the borehole into a horizontal pipe. The pipe must be completely full of water with straight cut ends (not jagged). This will obviously be more useful on wells with large flows. This also may be tricky as the water level may need to be above the pipe for it to run full, but not high enough to overflow the pond dam or ditch diverting it into the pipe. The volume of water exiting this pipe can be determined by the formula:

Well Flow in gal/min = 1.05 x (area of end of pipe in square inches) x (distance in inches from end of pipe to a point where the falling water is one foot below the top of the pipe)

To determine the area of the end of the pipe in square inches:

$$Area\ (square\ inches) = 3.14\left(\frac{Diameter(inches)}{2}\right)^2$$



APPENDIX 2

TECHNIQUES TO MEASURE DEPTH OF WATER IN A WELL DURING A PUMPING TEST

A sonar or ultra-sonic device can be placed at top of the well casing that bounces a sound wave off the water.

Sonar or ultrasonic device.

Electronic water level indicator.

Most water level indicator devices use paired electrodes that complete the circuit only when water is contacted so they must be submerged in the well. It is important to place this type of device inside of a small pipe that extends almost all the way down to the pump. (See photo on cover) This will prevent false indications of water level, if water is falling into the well from a water zone higher than the current water level.

Pressure transducers are very sensitive devices and may be dangled in the well or attached to the pump at a depth measured with a tape for calibration purposes. They will measure changes in pressure and can usually be programmed to record at very short intervals. These pressure transducers have an advantage over paired electron water level indicators in that water falling into the well from above does not affect them and they do not need to be in their own separate conduit. These are also great for use in nearby observation wells as they require no manpower during the actual pump test. You set it and retrieve it and the data after the pump test is completed. They are sensitive enough that when used in nearby monitoring wells they can help deduce other factors that may be affecting the water level in the well being pumped, such as, air pressure changes if atmospheric barometric pressure is also monitored during the test, earth tides, trains going by, etc.

APPENDIX 2 (Continued)

Pressure transducer

Install a piece` of tubing (known as an airline) that is connected to the pipe (plastic zip tie bands work well for this) just above the well pump to determine the amount of water above the pump. This tube should be long enough to run from the well pump to several feet out of the well casing at the ground surface. On the end of the tube at the ground surface attach a tee to this tube with a Schrader valve on one end and a pressure gauge on the other. Use an air compressor or a tank of compressed air to pressurize the tube by connecting it to the Schrader valve and allow air to flow into the tube. The pressure gauge will then reflect the pressure caused by the weight of the water above the tube pressing on the air in the tube.

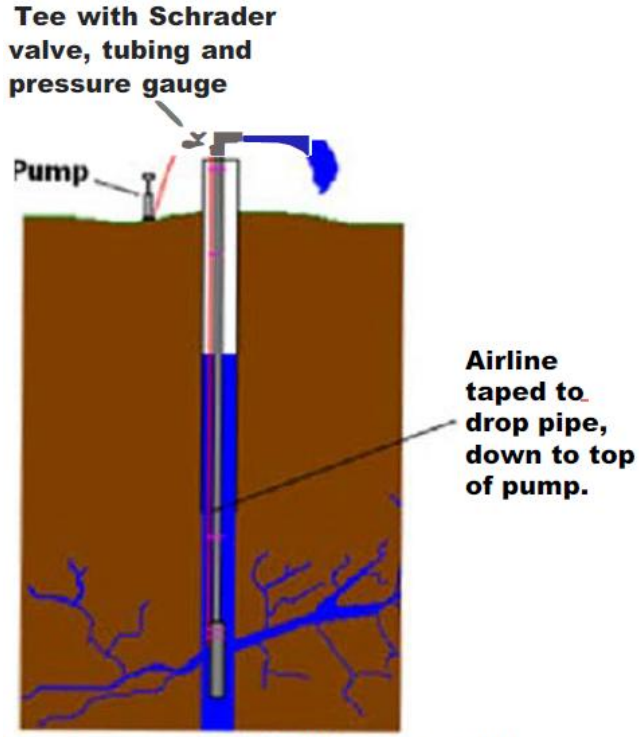
Water above end of tube = air line pressure x 2.31 ft/psi

Depth to water = depth of bottom of tube – water above end of tube

Example: Pressure gauge reads 5 psi, with bottom of tube at 85 ft below ground surface.
Water above end of tube = 5 psi x 2.31 ft/psi = 11.55 ft
Depth to water = 85 ft – 11.55 ft = 73.45 ft

APPENDIX 3

OTHER CALCULATIONS NEEDED TO COMPLETE THE VIRGINIA DEPARTMENT OF HEALTH PUMPING TEST FORM



Pressure gauge and airline assembly used to measure water level in a well.

Drawdown Rate (ft./hr.) is calculated by subtracting the depth to water reading from the last depth to water reading to get drawdown depth in feet. Use the following formula:

Draw Down Rate (ft./hr.) = (Current reading for Depth to Water - Previous recording for Depth to Water x 60 min/hour) ÷ minutes since last reading

Well Recovery:

Recovery (ft/30 minutes) = (Last Depth to Water Reading - current Depth to Water reading)

APPENDIX 4

Well Yield and Recovery Report

System Name			City/County				
Well Number and Name			Well Class		Well Casing Size		
Well Depth (ft.)		Static Water Level (ft.)		Depth of Pump (ft)		Airline Length (ft.)	
Test Pump Brand/Model			Pump HP				
Name & Address of Company Performing Test							

Well Yield

Date & Time Test Started

Notes: All measurements are from top of casing
(1) Water Above Pump = Air Line Pressure x 2.31ft./psi + (Pump Depth - Air Line Length)
(2) Depth to Water = Air Line Length - (Air Line Pressure x 2.31ft./psi)
(3) Depth to Water = distance from top of casing to water level

Time	Time of Reading	Air Line Pressure (psi)	Water Above Pump (ft.)	Depth to Water (ft.)	Draw Down Rate (ft./hr.)	Meter Reading (gal)	Pump Discharge Rate (gpm)
Start							
5 min							
5 min							
5 min							
5 min							
5 min							
5 min							
15 min							
15 min							
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1 hr							

Well Yield (cont.)							
Time	Time of Reading	Air Line Pressure (psi)	Water Above Pump (ft.)	Depth to Water (ft.)	Draw Down Rate (ft./hr.)	Meter Reading (gal)	Pump Discharge Rate (gpm)
1 hr							
1 hr							
1 hr							
1 hr							
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Well Recovery

Date & Time Test Started

Notes:
(1) Well recovery period shall start as the pump test ends
(2) Well recovery period shall be 30-minute intervals for 2-hours

Time of Reading (30 minute interval)	Air Line Pressure (psi)	Water Above Pump (ft.)	Depth to Water (ft.)	Recovery (ft./30 minutes)

Notes

Preparer's Signature

Date