WATER FACTS 3

Using Low-Yielding Wells

There are several steps that can be used to increase the adequacy of a low-yielding well.

What Is Well Yield?

Private wells are frequently drilled in rural areas to supply water to individual homes or farms. The maximum rate in gallons per minute (GPM) that a well can be pumped without lowering the water level in the borehole below the pump intake is called the well yield. Low-yielding wells are generally considered wells that cannot meet the peak water demand for the home or farm.

Peak Demand

Dealing with low-yielding wells requires an understanding of peak demand. A well that yields only 1 GPM of water can still produce 1,440 gallons of water in day. However, water use in a home or farm does not occur evenly during the day. There are peak usage times, typically during the morning and/or evening, when water demand is very high. These peak demand periods usually last from 30 minutes to 2 hours. An adequate water system must yield enough water to satisfy a peak demand for at least 2 hours.

Let's look at an example of how a low-yielding well can fail to meet peak demand. A family of four lives in a home with a well that yields about 1 GPM. On a typical Saturday morning, there may be a 2-hour peak demand period where water is used for multiple loads of laundry, breakfast dishes, showers, toilets, and sinks. Without water-saving appliances and fixtures, the water use during this 2-hour period could exceed 300 gallons. A 1-GPM well could only provide 120 gallons of water during this peak demand period, far short of what would be needed.

Ideally, peak demand is determined for the home or farm before the well is drilled. That way the well and water system can be designed to meet the peak demand. Consult Water Facts #2, Water System Planning—Estimating Water Use, and Before You Drill a Well to learn more about steps to take to plan for a new well. Both of these articles can be obtained at the Penn State Extension Water Quality website or from your local county Penn State Extension office.

So what can be done if an existing well is not meeting peak water demand? The options generally fall into two categories: reducing peak water use or increasing storage within the water system.

1) Reducing Peak Water Use

Peak water demands on the well can be reduced by changing the timing of water-using activities or by reducing the amount of water used. Examples of changing the timing of water use include spreading laundry loads throughout the week instead of doing all loads in one day and having some family members shower at night rather than all showering in the morning.

Reducing the amount of water used involves water conservation. This might include changes in water-use behaviors such as taking shorter showers or not washing the car. Changing water-use behavior to spread out peak water-use may be inconvenient at times but there is no added cost involved. A more permanent but costly water-conservation solution is to install water-saving devices like front-loading clothes washers or low-flush toilets. The use of a front-loading washer alone will save more than 20 gallons of water for each load of laundry. Research has shown that installation of water-saving devices and appliances can reduce household water use by up to 30 percent and also save hundreds of dollars per year in energy used for heating water. Examples of typical water savings from various appliances and fixtures are given in Table 1.

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Clothes Washer	
Top-loading	51 gal per load (GPL)
Front-loading	27 GPL
Water savings	24 GPL
Toilet	
Standard	5 gal per flush (GPF)
Low-flush	1.6 GPF
Water savings	3.4 GPF
Faucets/Showerheads	
Standard	3 gal per min (GPM)
Low-flow	0.5 to 2.5 GPM
Water savings	0.5 to 2.5 GPM
Dishwasher	
Standard	14 GPL
Water efficient	4.5 to 7 GPL
Water savings	7 to 9.5 GPL

Table 1. Water use and savings for various fixtures and appliances in the home.

The initial cost to retrofit the home with all of these water-saving devices would probably cost between $1,500 and $2,000. To learn more about water and energy savings through household water conservation, consult the cooperative extension publication entitled Household Water Conservation, available from your local cooperative extension office or online at the Penn State Extension Water Quality website.

2) Increasing Water Storage

Inadequacies in the well water yield can also be compensated for by increasing the amount of water stored within the water system. Added storage can be achieved in a pressure tank, a large storage tank (intermediate storage) or in the drilled borehole.

Pressure Tank Storage

The pressure tank allows a water system to operate automatically. It is, in a sense, a storage tank—but it has very limited storage capacity. Its primary purpose is to create and maintain pressure on the water in the pipeline.

As water from the source is pumped into the tank, the air in the space above the water is compressed. When the pressure on the surface of the water reaches about 40 pounds per square inch (psi), a pressure activated switch stops the pump. When a faucet is opened, the air pressure forces the water out of the tank through the pipeline until the pressure drops to about 20 psi. Then the pressure regulator trips the switch and starts the pump, which forces an equal amount of water back into the pressurized tank.

About 20 percent of the capacity of the pressure tank contains usable water. A 42-gallon tank will discharge about 8 gallons before the pump starts; (an 82 gallon tank—16 gallons; a 120 gallon tank— about 24 gallons). Thus, larger pressure tanks alone will provide slightly larger amounts of stored water, but the increased storage is not enough to solve problems with a low-yielding well.

If water conservation is not sufficient to reduce peak water demand to satisfactory levels, an intermediate storage water system may provide a cost-effective and reasonable solution to the problem.

Intermediate Storage

An intermediate storage system is simply a storage reservoir that is added to receive water from the well to meet peak water demand on the home or farm. A typical system is shown in Figure 1. Intermediate storage systems are based on the concept that many low-yielding wells can provide a constant but limited flow 24 hours per day without appreciable drawdown. In this case, a normal well pump may cause the water level to drop to a critical point during periods of high use, and the pump will not be able to obtain the water needed to replenish the pressure tank at the rate at which it is withdrawn.

This problem can be solved by installing an intermediate storage reservoir between the well and the pressurized distribution system. This reservoir then serves as the primary source of supply for the pressure pump.

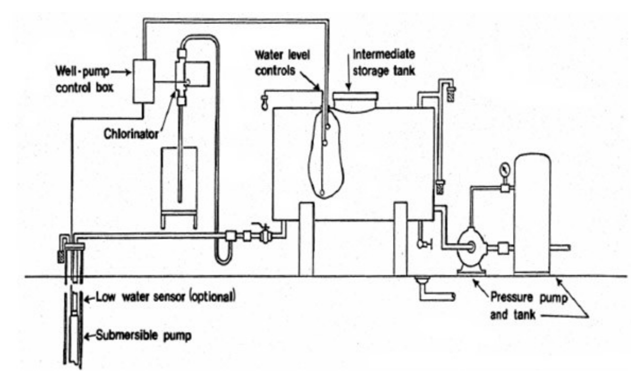

Figure 1. Schematic diagram showing the typical components of an intermediate storage system.

An intermediate storage water system requires two pumps and a large holding tank or reservoir. The pump in the well pumps water into the reservoir; the pressure pump transfers the water from the reservoir to the pressure tank and into the distribution system.

The intermediate storage tank is a nonpressurized tank or cistern, usually installed at about the same elevation of the building in which water is to be used. The depth of water stored in the nonpressurized storage reservoir is regulated either by float switch or water-level sensor that controls the on-off operation of the well pump.

Storage Tank Capacity

There are many types of storage tanks that can be installed to provide intermediate water storage. Most tanks are made of plastic or concrete. In some instances, it may be desirable to install two intermediate storage tanks in parallel rather than one larger single unit. This arrangement provides some flexibility in that one tank can be removed from service for cleaning and maintenance while the other keeps the water system in operation.

For home water systems, the tank(s) must be protected from freezing by either burying them below the frost line or placing them in a heated garage or basement. Storage tank capacity for a residential home should be sized based on the number of people living in the house. Ideally, the storage tank(s) will hold enough water to meet a full day’s water use. The tanks can then be slowly refilled overnight from the low-yielding well. As a rule of thumb, size the tank to allow for 100 gallons of water for every person in the home. So, a family of five would need 500 gallons of storage in one or more tanks. Additional capacity should be provided if you foresee increased water demands in the future. A 300- to 500-gallon storage tank will range in cost from $250 to $500. Intermediate storage tanks for farming operations are typically much larger and would be sized based on the daily use of water for the farm. At a minimum, the storage tank(s) should be large enough to satisfy 2 hours of peak water use but, ideally, the tanks should be large enough to store water for an entire day. In addition, it would be wise to plan additional water storage for emergency use, such as fire protection. If the farm water use in unknown, it can be estimated using values from the fact sheet entitled Water Facts #2—Water System Planning, Estimating Water Needs. The U.S. Department of Agriculture recommends a capacity of at least 2,000 gallons for an intermediate storage tank. Costs for large storage tanks vary from $500 (1,000 gallons) to $1,500 (3,000 gallons). Storage tanks for farm water should also be protected from freezing unless water use tends to be continuous enough to prevent freezing.

Whether they are used for home or farm water systems, intermediate storage tanks can also serve to aid in water-treatment processes. If chlorine is used to disinfect the water supply, the storage tank may increase the water-chlorine contact time needed to destroy disease-producing bacteria and reduce the amount of chlorine required. The storage also serves as a treatment tank in which dissolved iron compounds oxidized by the chlorine are precipitated out of solution and settle to the bottom. Clear water remaining in the upper part of the tank is pumped into the pressure tank and distribution system.

Pressure Pump Capacity

A pressure pump is typically added after the intermediate storage tank(s) unless the system can be gravity fed to the home or barn. The pressure pump provides water to the pressure tank for distribution in the home or farm. The capacity of the pressure pump can be determined by estimating the total daily water requirement from the well (see Table 2 in Water System Planning—Estimating Water Use). Larger pressure pumps are required for farms where water demand is higher.

Well Pump Capacity

The well pump for an intermediate storage water system should have a rated pumping capacity slightly less than the yield of the well. The pump should be expected to operate more or less continuously, if necessary, to keep the storage reservoir full. Normally, a low-water cut-off switch controlled by water-level sensors in the well should be connected to a relay at the pump switch box. A low-water signal relayed to the main switch should override other pump controls and stop the pump if the water level drops to a critically low point where air or sediment would be pulled into the system.

A schematic arrangement for an entire intermediate water-storage system is shown in Figure 1. Note that this diagram includes a chlorinator between the well, and the nonpressurized storage tank and the water level sensors in the tank. A sensing device for a lowlevel water cut-off switch in the well should be installed to protect the well pump. The typical cost for a household intermediate storage system (without the chlorinator) would probably be less than $1,500, depending on the amount of labor. A larger farm intermediate storage system would be closer to $3,000, but may be significantly more if very large amounts of water must be stored.

Borehole Storage

A final method to better utilize a low-yielding well is to increase the storage of water within the borehole. The borehole may be able to store several hundred gallons of water to meet peak water demand. Ideally, extra borehole storage is added to a lowyielding well when it is first drilled to meet the expected home or farm water demand (see Water Facts #2, Water Systems Planning—Estimating Water Use for more details on water system planning).

The amount of water stored in a well can be increased by widening or deepening the well borehole. For example, a typical 6-inch diameter well with 100 feet of water in the borehole would store 147 gallons of water. If the 6-inch well were replaced with a 10-inch diameter well, the storage would increase dramatically to 408 gallons of water. The additional 261 gallons of stored water may be sufficient to serve a single family home even if the well yield is very low. Increasing diameter alone should not change the water quality conditions from the well since it still draws water from the same aquifer. However, increasing diameter alone is risky because its success depends on a relatively constant depth of water in the well. In reality, the depth of water in the well may vary dramatically during wet and dry periods, causing the change in storage to also vary considerably. For example, a well that typically has 100 feet of water may have less than 20 feet of water storage during a drought. As a result, increasing the diameter of this well from 6 inches to 10 inches would only increase the water storage by about 50 gallons during a drought—far less than would be needed to meet peak water demand.

In wells where the water level changes significantly during dry periods, deepening the well may be a better alternative to increase borehole storage. Drilling an existing 6 inch diameter well 100 feet deeper would increase the water storage by 147 gallons. There can be, however, significant changes in water quality as you deepen an existing well. The deeper well may access groundwater with natural or manmade pollutants that may require the addition of water-treatment equipment. Consultation with a local, experienced well driller as well as nearby well owners will be helpful in determining the risk of drilling an existing well into deeper groundwater.

Cost is an obvious consideration when increasing the diameter or depth of an existing well. Well components like the pump, wiring, conduit, and casing would need to be removed before the existing well could be re-drilled. Further costs would be based on a per-foot drilling cost from the contractor. Some drillers may prefer to simply drill a new well to the new specifications rather than alter the existing well. Regardless, drilling a wider and/or deeper well will usually cost more than the purchase of water conservation devices or installation of an intermediate storage system.

A Final Word

A low-yielding well does not have to be a source of persistent concern for a homeowner or farmer. The methods described in this fact sheet can often be used to make these wells meet peak water demands. Simple changes in water-use habits may be enough to meet peak water demands where water shortages occur infrequently.

If larger water savings are needed, water-saving devices and appliances offer large water savings and easy installation for moderate costs. More serious cases, where water availability routinely fails to meet peak water demand, warrant installation of an intermediate storage system. Increasing borehole storage may also be an option, but this method is less predictable and more expensive in many cases. A local water well contractor can provide guidance and a cost estimate to increase borehole storage.

Additional Resources

For further information on management of wells and springs in Pennsylvania, visit the Penn State Extension Water Quality website or contact your local extension office.

Contact Information

Bryan Swistock
Senior Extension Associate; Water Resources Specialist
brs@psu.edu
814-863-0194

extension.psu.edu

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