FACT SHEET

# RECOMMENDATIONS FOR CONSTRUCTION OF PRIVATE WATER WELLS IN BEDROCK

PA Department of Conservation and Natural Resources
Bureau of Topographic and Geologic Survey

## BACKGROUND

This fact sheet contains guidelines for homeowners and contractors on the construction and maintenance of bedrock water wells. This is the most common type of private water well in Pennsylvania.

The average well is a borehole that is drilled into rock where it intercepts groundwater in fractures in the rock aquifers. A protective casing from the surface to solid bedrock is used to keep soil and weathered rock out of the borehole.

The use of these guidelines will provide for better protection of private water wells. Careful placement and proper construction are probably two of the most effective steps that people can take to protect their wells. Water testing is the only way to be certain that the water is safe to drink.

The state of Pennsylvania does not regulate the construction details of private water wells. State law does require drillers to have a Water Well Driller's license and a valid rig permit. Drillers also must provide to the state and homeowner a copy of the Water Well Completion Report, which describes where, when, and how the well was constructed. Even so, no state requirements exist for location, construction method, materials, yield, or water quality. As a consequence, Pennsylvania homeowners who rely on private water wells must act as caretakers of their own water supplies.

A few municipal and county governments have passed standards for private water wells. Federal mortgages for housing may require certain water analyses for the well. Other lending institutions may have sampling requirements. Outside of these instances, however, water well owners must take responsibility for the water quality and maintenance of their water well.

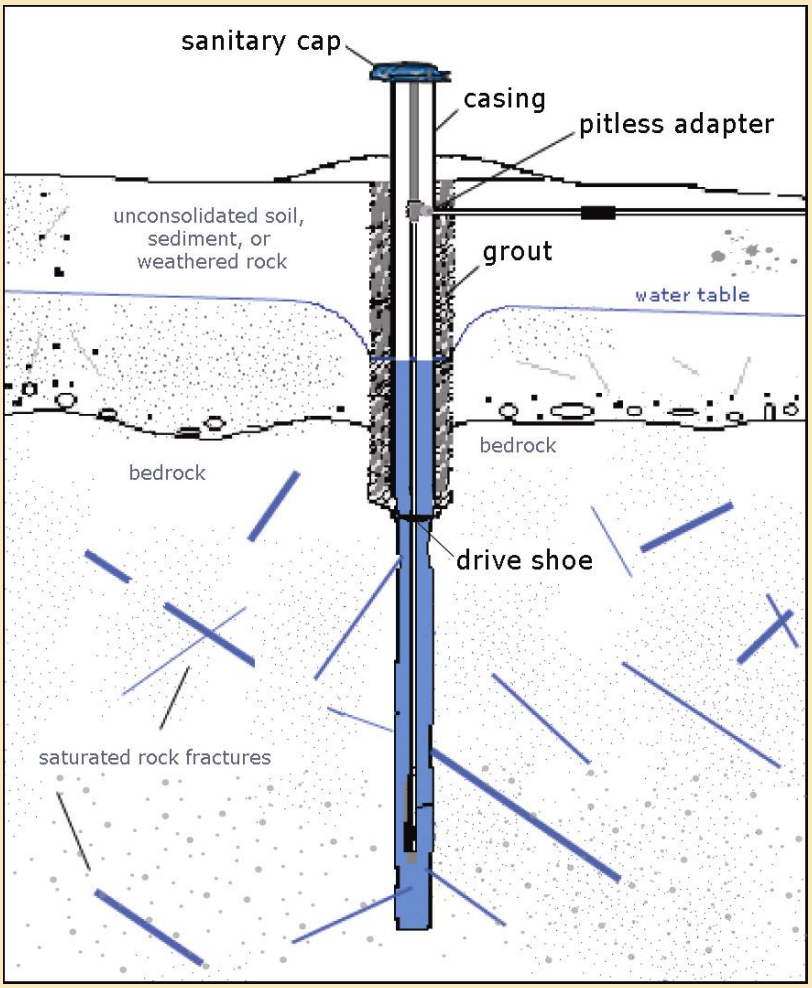


Figure 1. Components of an open-hole water well located in bedrock. Blue lines represent saturated fractures in bedrock.

## Siting the well

As a first defense, wells should be sited at least 100 feet away from sources of contamination such as septic system leach fields, roads, fuel tanks, and barnyards. Ideally, the well will be uphill from pollution sources because groundwater flow typically mimics the direction of surface topography, flowing from areas of higher elevation to lower elevation. If there is a source of pollution uphill, there is a better chance a well downhill will intercept it.

## Recommended construction for bedrock wells

Combining prudent well siting with sound construction practices will go a long way toward protecting groundwater quality and the user's health. The homeowner can require the driller to construct a well that protects the water supply. This is more expensive than a traditional well with no such features; however, the increased cost of constructing a "sanitary well" may be offset by savings associated with better health of users, protection of the water resource, and the avoidance of costly water treatment equipment in the future.

It is recommended that the driller construct the well in two steps. The first step is to drill the hole into firm bedrock, install protective casing, and add grout (typically cement-based) to secure the casing in place. The second step would be to drill the hole to its final depth (after allowing the grout to cure). There may be situations where grouting could be effectively done after completing all the drilling. In any case, care should be given to remove pathways for water along the casing, and to make sure that grout is not placed into the open-rock portion of the well.

## Parts of the well

***Casing*** – Drillers typically install a steel casing to keep the loose rock and soil from collapsing into the water well (Figure 1). Casing should be new, clean, and meet ASTM (American Society of Testing and Materials) standards. Casing should be a minimum of 20 feet in length and extend at least five feet into solid bedrock. Finally, the casing should extend at least 12 inches above land surface, and more if the area collects surface runoff or is subject to flooding. A driller may opt for plastic PVC (polyvinyl chloride) casing because of the presence of corrosive groundwater. Plastic casing is resistant to corrosive waters and so may be a good choice in this situation.

Figure 2. Drive shoe.

***Drive shoe*** – In most cases, a drive shoe (Figure 2) should be used to protect steel casing from cracking and splitting when placed into bedrock. A drive shoe is welded onto the bottom of the casing as a reinforced part that can withstand the stress as it is driven into bedrock.

Figure 3. Pitless adapter.

***Pitless Adapter*** – This device redirects water laterally below the frost line from the well to a nearby storage tank in the house (Figure 3). It allows the well casing to extend above the ground surface. The pitless adapter should be made by a reputable company and installed so that it is watertight. Pitless adapters can be used with steel or plastic casing.

***Casing Grout*** – When a casing is placed in the borehole, an annular space is created between the wall of the borehole and the casing (Figure 4). If not properly sealed, this space becomes a pathway for shallow groundwater and surface water, which is potentially contaminated, to enter the well. To remove the threat, this space should be filled with a watertight material, such as a cement-based grout, or a grout and clay mixture. The grout prevents surface water from seeping down along the casing directly into the water well. To ensure a watertight seal, the grout should be added from bottom to top. This is typically done by placing a pipe down along the casing and pumping the sealant as the pipe is removed. The grout should be added from the casing bottom to at least the base of the pitless adapter. For long casing lengths, the driller should grout at least 30 feet of casing.

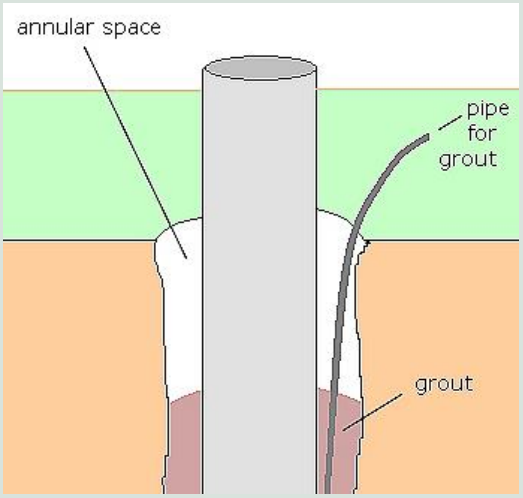


Figure 4. Annular space around the casing.

When PVC casing is used, the driller must take care to construct an effective seal while keeping the casing from cracking or breaking. Bentonite or a Jaswell-type seal can be effective in sealing the annular space around the PVC casing. Cement grout, which releases heat as it cures, should not be used because it can soften the PVC casing.

***Cap*** – The well should be topped with a tamper-resistant and vermin-proof, vented cap. This type of cap has a rubber seal that keeps insects out of the well. A screened vent allows any type of subsurface gases to escape rather than build up in the well or follow the piping into the house.

## Development, yield, and disinfection

After the well is drilled, the driller should develop the well by cleaning out sand, silt, and clay from the borehole. This helps to extend the life of the well and improve its water quality.

The driller typically estimates the well's yield in gallons per minute. A two- to four-person household on average requires 125-250 gallons of water per day. A six-inch borehole will store about 1.5 gallons of water per linear foot of the well. Not all well yield estimations are accurate. A pumping or aquifer test, where water is pumped at a specific rate while the water level in the well is monitored, allows for a better estimate of well yield than a driller's visual estimate.

After developing the well, the driller should disinfect the well to kill any microorganisms that might have been introduced during construction. This is typically done through chlorination and is called "shocking" the well.

The driller must provide a copy of the well construction record to the owner, who should keep it as a permanent record. Information on the well depth, static water level, well yield, and the depth of the pump (if installed by the driller) should be included. In addition, the driller's log of the subsurface should provide a description of what was encountered as the well was drilled. This would include the depth of rock layers and aquifer characteristics. As a final step after the well is completed, the ground should be sloped away from the top of the well casing (burying the well casing is not recommended).

## Reasons for concern

Millions of Pennsylvanians get their water from private water wells. Although some areas have meager amounts of groundwater, adequate water supplies for a single family home can be found on average, just about anywhere in the state. Except in severe drought, dry wells are not common. More common in Pennsylvania are water wells that have poor water quality.

In the past, groundwater was thought to be protected from pollution by the soil layer. We now know that is not always true. Water can pass through the soil with limited filtering of contaminants in many areas (for example, in areas with shallow bedrock or a high water table, or limestone areas with sinkholes that directly connect surface water with groundwater).

Poor well construction is a key factor in the presence of bacteria (like coliform bacteria) in water wells. In a 1996 study of the Lower Susquehanna River basin, the U.S. Geological Survey (USGS) found that "nearly 70 percent of the [146] wells sampled had total coliform present and thus were not suitable for drinking without treatment." The USGS concluded that poor well construction can allow contaminated surface or shallow groundwater to directly enter the well. A 2001 study documented the relationship of non-sanitary wells with the presence of *E. coli* bacteria. More recent research (2009) conducted by the Pennsylvania Master Well Owner Network showed that poor well construction is correlated with bacterial contamination.

Complicating this threat is the fact that contamination can be sporadic and often does not affect taste, appearance, or odor of the water. Although not "fail-safe," a properly located and constructed well minimizes the chance of contamination entering the well, thereby keeping the people who drink the water healthy.

## After the well is drilled

In Pennsylvania, most groundwater flow is local. Water drawn from a well most likely fell nearby as rain or snow. Well owners should avoid problems by creating their own "wellhead protection areas." This involves keeping potential contaminants away from the well. Responsible land use practices can pay off by protecting water quality. Here are some examples of wise practices:

- Keep livestock and the family pet away from the well.
- Don't landscape or add mulch directly around the well.
- Be careful where you dispose of waste or where you wash equipment. Don't dispose of waste into basement or garage floor drains.
- Take used oil to a recycling center. Don't dump it on the ground.
- Mix pesticides or paints over a sidewalk or concrete pad, away from the well; apply fertilizers and pesticides with caution and follow directions on the label.
- Don't allow back-siphonage to occur from a container or tank into a well. Install a backflow preventer or keep hoses out of mixing containers or tanks.
- Properly dispose of household chemicals and trash. Don't use sinkholes as dumps because sinkholes can be a direct connection to groundwater.
- Properly seal old abandoned wells.

An annual check on the well and its water quality and quantity is a good idea. Water wells typically do not last forever. Wells may need to be cleaned out or rehabilitated after years of use. Any changes in water quality or diminished water quantity should be cause for action.

## Testing the water

Sanitary well construction is no guarantee of good water quality. If the aquifer is polluted, then the construction of the well won't help. The water may look fine and even taste good, but it could contain contaminants. For this reason, the water should be tested promptly after the well is drilled and then on a yearly basis for total coliform bacteria, at a minimum. If coliform bacteria are detected, then a test for *E. coli* bacteria should be done. In addition, it is recommended that every few years the well owner test for pH, total dissolved solids, and any other locally significant parameters like hardness, sodium, chloride, nitrates, hydrogen sulfide, iron, barium, and/or manganese.

What is tested for depends on potential sources of contamination, as well as the general quality of the water. Some homes might be tested for copper and lead if they contain older plumbing materials. It is recommended that a laboratory certified for drinking water by the Pennsylvania Department of Environmental Protection (DEP) be used for the analysis. A list of certified laboratories can be obtained from DEP's website. Detection of a contaminant or elevated levels of some substances may require that the water be treated. See links under Resources below for more information on testing and treatment.

## Resources

- Pennsylvania Department of Conservation and Natural Resources, Geology, http://www.dcnr.pa.gov/Geology
- Master Well Owner Network, https://extension.psu.edu/programs/mwon
- Pennsylvania Department of Environmental Protection, http://www.dep.pa.gov
- Pennsylvania Ground Water Association, http://www.pgwa.org
- U.S. Environmental Protection Agency, Private Drinking Water Wells, https://www.epa.gov/privatewells
- U.S. Geological Survey, Pennsylvania Water Science Center, https://pa..water.usgs.gov
- National Ground Water Association, Wellowner.org, http://wellowner.org

*All website links verified January 9, 2018*

## MORE INFORMATION

This fact sheet was adapted from a similar fact sheet by DEP staff. Thanks to Kristin Carter, Gary Fleeger, and John Harper of the Pennsylvania Geological Survey who provided thoughtful reviews. For more information on water wells, contact the Pennsylvania Geological Survey at (717) 702-2017.

www.dcnr.pa.gov/conservation/water/groundwater

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