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Do Deeper Wells Mean Better Water?

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How deep should a well be? When is a well considered "deep"? Do deeper wells always provide better quality water?

This publication looks at these questions to help you understand important differences in water quality that can occur between shallow and deep wells. You'll learn where the water in your well originates. You'll discover that a "shallow well" in one location might be a "deep well" in another part of the county or state. And you'll learn why, in some cases, a shallow well is actually a better choice than a deep well.

The information presented here focuses on domestic wells that draw water from sand and gravel, but it generally applies to bedrock aquifers as well.

How deep should my well be?

To answer this question, consider the following points.

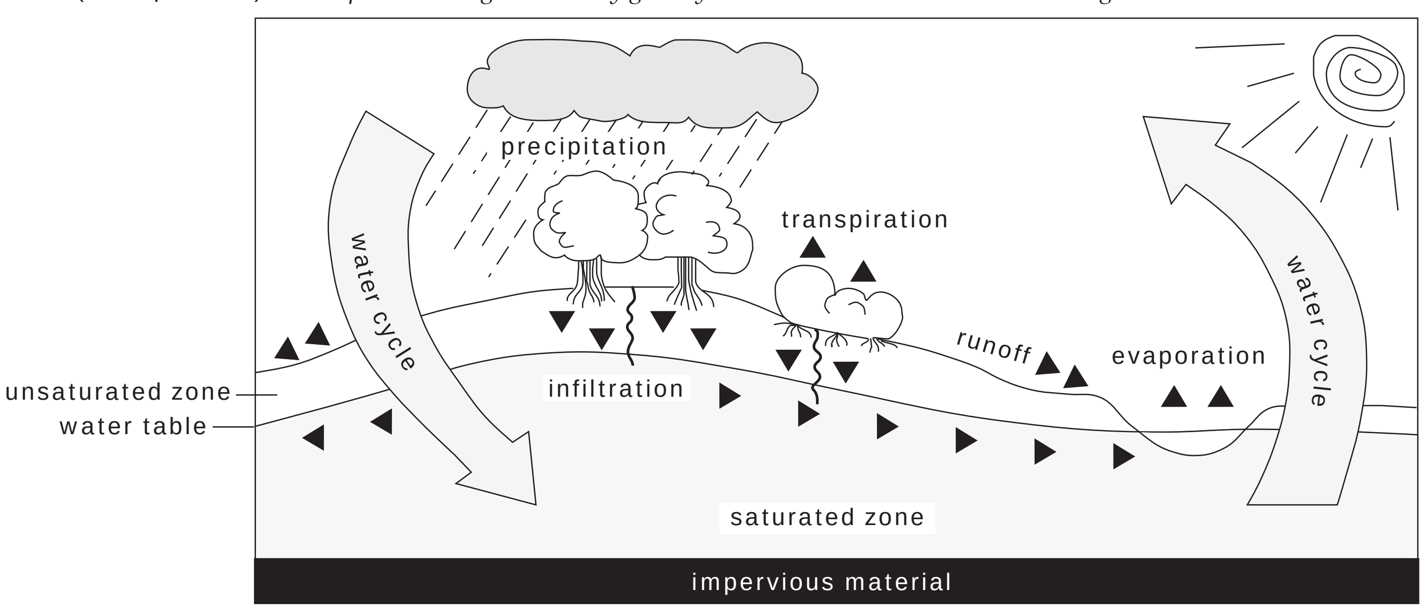
Wisconsin's groundwater comes from the sky.

The water pumped from wells is called *groundwater*. Contrary to popular myth, the state's groundwater does not come from underground rivers, Lake Superior or Canada. Rather, groundwater starts as precipitation that soaks into the ground, usually within a few miles of your well. Groundwater is part of nature's *water cycle*.

Figure 1 helps you visualize underground water in the sand and gravel material found in much of Wisconsin. The upper layer of soil is known as the *unsaturated zone.* Pulled downward by gravity, the water in this zone moves slowly through pores in the soil, some of which also contain air. Below the unsaturated zone, the *saturated zone* (zone of saturation) exists, where all the pores between the sand grains and gravel particles are filled with water. The boundary between the saturated and unsaturated zones is called the *water table*.

Water in the saturated zone, below the water table, is called *groundwater.* The saturated sand and gravel is referred to as an aquifer. An *aquifer* holds water in the spaces between grains of sand or cracks in rocks, and transmits that water to wells.

Figure 1. *In the water cycle,* precipitation *which falls may* run off *into the stream or soak into the ground* (infiltration). *Some of the water that falls returns to the air by* evaporation *or passing through plants* (transpiration). *Water pulled through the soil by gravity into the* saturated zone *becomes groundwater.*



The shallower the well, the nearer to the well your water originates.

Figure 2 provides more detail about the possible pathways underground water may follow. It also shows several potential sources of groundwater contamination.

Various land uses and human activities, such as the septic system, barnyard or fertilized field in figure 2, may contribute to groundwater contamination. Gravity pulls water that soaks into the ground under these areas almost straight down to the water table. Contaminants may be dissolved and carried along as well. The soil filters out some of these materials, but may not be able to remove them all.

When water reaches the water table, it often changes direction. Below the water table, all the space between sand grains is already filled with water. As a result, incoming water moves laterally in the direction of regional groundwater flow, and slowly makes its way deeper into the aquifer as more water descends. That process is shown by the black arrows below the water table in figure 2. Groundwater moves quite slowly, even in sand and gravel—a few inches to a few feet per day.

Notice in figure 2 that the water flow to the shallowest well originates in the barnyard, while water in the deepest well comes from the woodland farther away. Figure 2 also illustrates how the normal direction of groundwater flow can be temporarily changed by well pumping. Pumping causes a temporary lowering of the water table around the well called a cone of depression.

Groundwater flows in a given direction.

Another observation you might make about figure 2 is that all the groundwater moves from the right side of the drawing to the left. Besides flowing downward, groundwater also moves across a region from higher to lower elevation. Groundwater is recharged, or replenished, in upland areas. It generally moves toward low areas such as lakes, streams and wetlands, where it discharges as it reemerges from the ground as seepage or spring water. The distance that groundwater can flow in Wisconsin is limited, however. Most groundwater from home wells—even the deepest ones—comes from within a few miles away. And as we've already seen, the shallowest wells generally pump up water that originates in your own backyard.

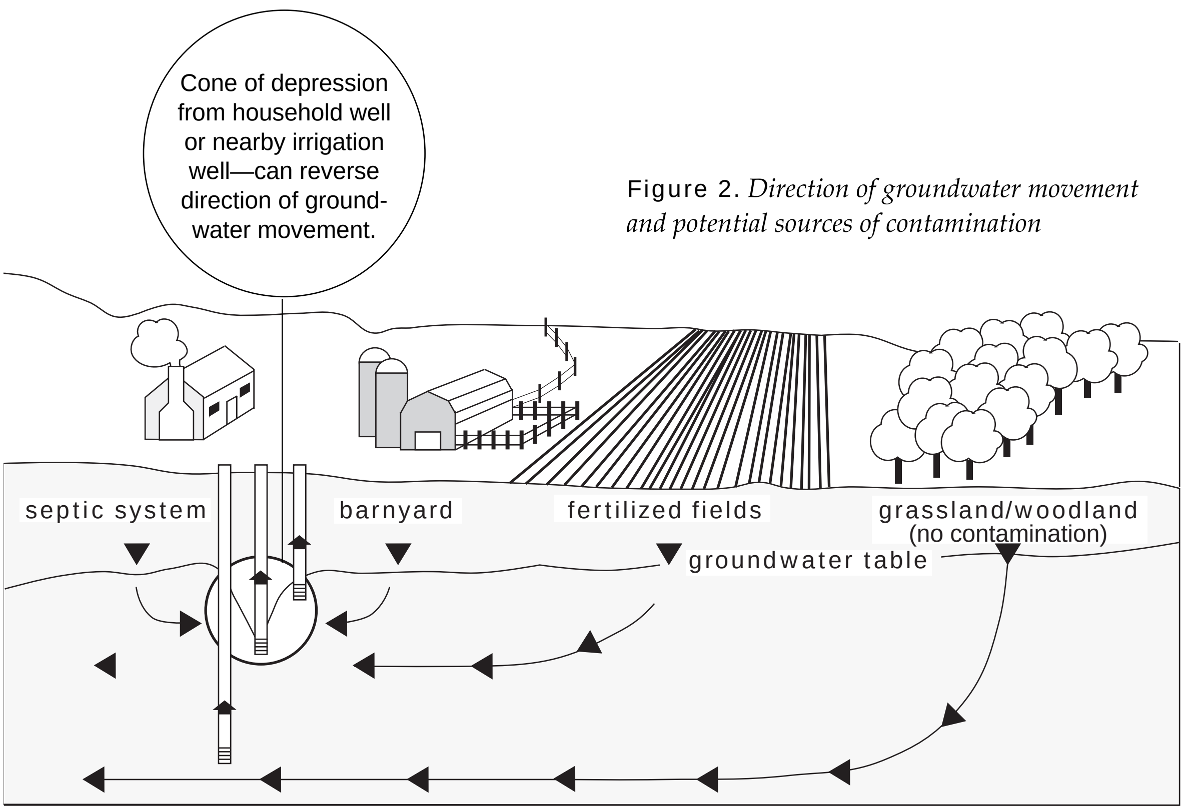


Figure 2. *Direction of groundwater movement and potential sources of contamination*

Knowing the direction of groundwater flow helps you determine the most desirable location and the appropriate depth for your well. For example, in figure 2, a well owner might look at the land uses *upgradient*, or uphill in the groundwater flow system. Knowing that several potentially polluting land use activities were conducted near the well site, and that a natural area was located farther upgradient might help a well owner decide that a deeper well would provide better quality water. Failing to consider groundwater flow direction and well depth might lead to unintentionally "recycling" water from the barnyard.

But determining the direction of groundwater flow in the hilly, glaciated areas of Wisconsin can be a complicated matter. If the land around you slopes toward a major stream, such as the Wisconsin River, you can assume that the groundwater underneath your land flows toward the river. But when you look at groundwater flow around a groundwater seepage lake, you may actually find that groundwater flows into the lake on one side and back into the ground on the other! Some counties have groundwater elevation maps that can help you determine the direction of groundwater flow in your area. Check at your county Extension office or the Wisconsin Geological and Natural History Survey at the address listed on the back page.

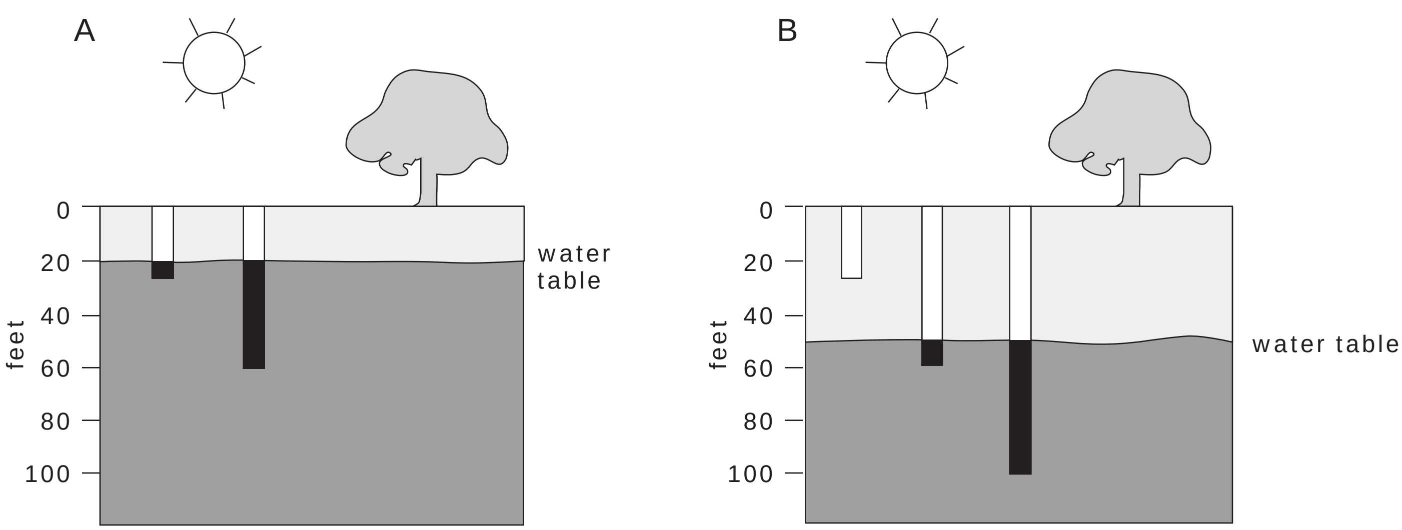
"Shallow well" and "deep well" are relative terms.

When is a well considered "deep"? The most important aspect of depth is not the well's absolute depth—30 or 40 or 100 feet—but rather how far its *casing* extends below the water table.

Well depth can affect both the quality and quantity of water pumped from a well. As shown in figure 2, the quality of water in a well is influenced by the land use activities that take place in its recharge area. As for quantity, a well that is not deep enough to reach the water table will yield no water at all. Figure 3 shows two examples.

1. In location A, the depth from the land surface to the water table (the depth to water) is 20 feet. A 25-foot deep well would be a *shallow* well. It would be most susceptible to contamination from activities in the local area. Some part of the year it might be dry because of seasonal fluctuations in the water table. A *deep* well in this case might be 60 feet deep. Such a well would be better protected from local contamination and would not likely go dry even during drought years.
2. In location B, the depth to water is 50 feet. Our 25-foot deep well from the previous example is a dry hole. The 60-foot well is now a *shallow* well. It draws water from the top ten feet of the aquifer. It is susceptible to contamination from local activities, and might even be dry at times. If the water table is at 50 feet, a *deep* well might be 100 feet deep.

Figure 3. *"Shallow" wells and "deep" wells*



The amount of casing in a well is usually more important than the well's total depth

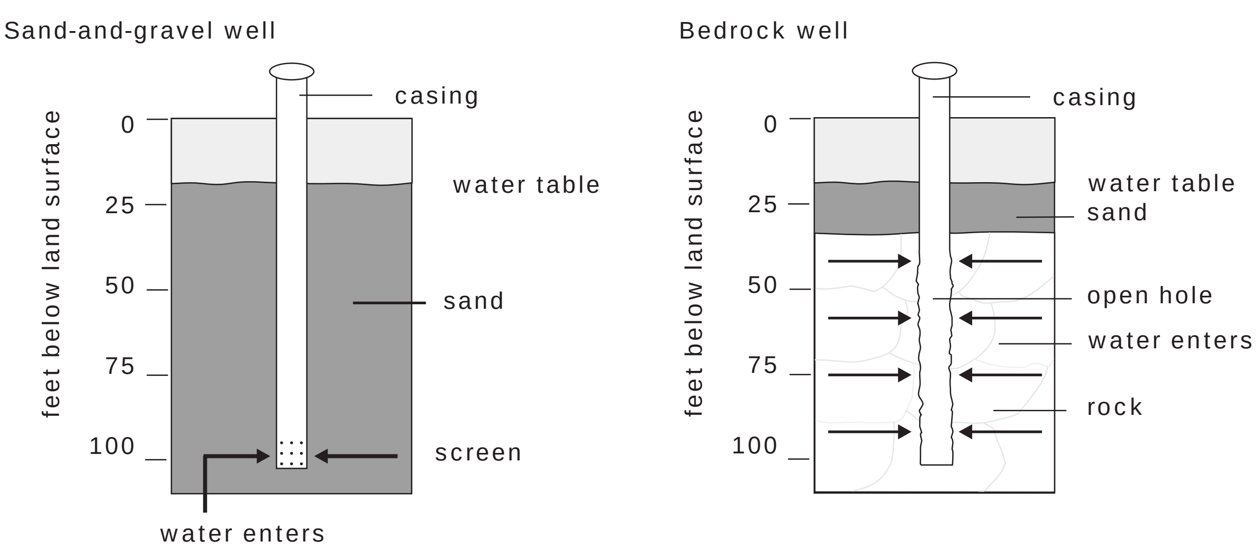
For many wells drilled into the sand and gravel aquifer, the amount of *casing*—the pipe that lines the well hole—is nearly the same as the depth of the well itself. For example, a well that is 100 feet deep may possess 97 feet of casing and a 3-foot section of screen at the bottom that allows water to enter. Without casing, sand and gravel would quickly collapse back into the hole, closing it (see figure 4).

Holes drilled into bedrock, such as granite or sandstone, stand small risk of collapsing. Therefore, it is not necessary to install casing all the way to the bottom. Rather, a minimum depth of casing is often installed while the remainder of the hole is left unlined, allowing water to flow into the hole from surrounding bedrock. For example, a well that is 100 feet deep in a sandstone formation may have 40 feet of casing and 60 feet of open hole below the casing. Groundwater may enter this well at any point below the end of the casing—in this case, at any depth below 40 feet.

In figure 4, both wells are drilled to the same depth into an aquifer. However, the well drilled into bedrock is able to draw water from a much shallower depth than the screened well drilled into sand and gravel. The depth of well casing can therefore be a very important factor in the quality of water taken from a well.

When applying the information in this publication to bedrock wells, it is important to substitute the words "shallow-cased" or "deep-cased" for "shallow" or "deep."

Figure 4. *Casing depth in a bedrock and a sand-and-gravel well*



Well depth and construction are regulated by the Wisconsin Department of Natural Resources (DNR).

Since 1936, well location and construction have been regulated by the Wisconsin DNR under chapter NR 112 (now NR 812) of the Wisconsin Administrative Code. All water-producing wells, whether constructed by licensed drillers or homeowners, must meet the minimum standards outlined by the code. The Well and Pump Installation Code describes proper well location, including minimum separation distances from potential sources of contamination. It also prescribes proper well construction techniques and materials. Minimum well and casing depths are given for specific geologic environments.

It is critical that you consult the Wisconsin well code for guidance on construction materials, techniques, and proper well location. (In addition, you should consider groundwater flow direction, which is not specifically covered in the code.) And remember that the code provides *minimum* standards, so you can take more precautions if you choose.

The DNR provides a basic summary of the well code requirements in its brochure titled *You and Your Well* (publication WS-002, 95 rev). For more detailed information about the well code, contact your DNR district private water supply specialist.

There are good reasons why you might want a deep well.

By now, you may be getting the idea that choosing the right depth for a well isn't always easy. If you install a shallow well, your water quality will be most influenced by your activities and those of your neighbors. If you install a deeper well, your water quality will be influenced by land uses farther uphill from you in the groundwater flow system.

There is one other element to consider in this problem, and that's the fourth dimension—time. The water that you draw from a deeper well is likely to be older, having been in the ground for a longer time than water from a shallow well. That fact gives rise to some important consequences.

1. The water quality you see in a shallow well today is probably the result of land uses in the past year or two. The water quality in a deep well may reflect land uses of ten or more years ago. If your neighbor spills five gallons of gasoline, it might show up in your shallow well fairly quickly. If the landfill a mile uphill leaks, it could take many years for the contaminants to show up in your deep well. Groundwater in the sand and gravel aquifer moves very slowly compared to water in streams—approximately a foot per day, or a mile in 16 years.
2. Water quality in a deep well usually changes more slowly than in a shallow well. That's because groundwater does some mixing as it moves through the aquifer. A spill a mile away from your deep well in the sand and gravel aquifer might be substantially diluted with clean recharge water before it gets to your well. Shallow wells are quite sensitive to what's going on immediately around them, and their quality may vary season by season.
3. Some chemicals, such as pesticides or gasoline residues, break down or change over time. If a pesticide soaked into the ground a mile away from you, it might be substantially changed in the time it would take to reach your deep well. In a shallow well, where your water may only have been in the ground for a year, there is much less time for such changes to occur.
4. In the sand and gravel aquifer, the shallowest groundwater may be the most corrosive. Shallow groundwater is often corrosive because the natural minerals which could protect against corrosion are depleted in the shallow parts of the aquifer. Corrosive water can damage metal, causing copper pipes to leak. When water is corrosive, lead solder (not allowed after 1984) that joins copper pipes can dissolve and enter drinking water at unsafe levels.

There are also good reasons why you might want a shallow well.

The fact that the water in a deeper well is older than the water in a shallow well has some benefits, as we saw earlier. However, that same fact can lead to several significant problems.

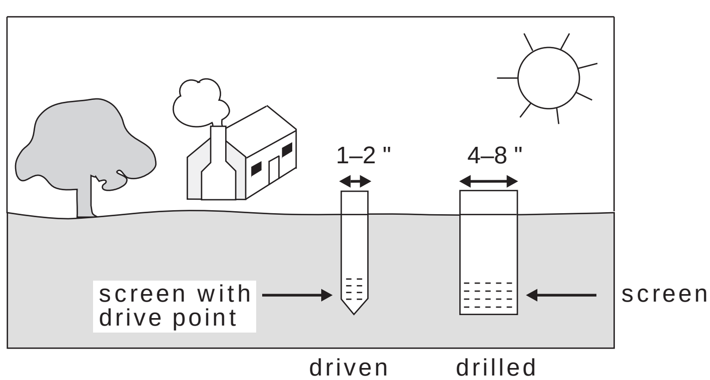
1. Deeper wells may possess higher levels of a number of naturally occuring nuisance and health-related contaminants. Minerals that dissolve in water such as calcium and magnesium (which cause hardness) are more plentiful deeper in the aquifer. Also, as the aquifer gets deeper, the amount of oxygen decreases, making it easier for certain minerals like iron and manganese to dissolve .
2. Deeper wells generally possess higher levels of naturally occurring radioactivity than shallow wells, especially when they come in contact with the crystalline bedrock aquifer underneath sand and gravel. Preliminary studies in northern Wisconsin have shown elevated concentrations of radium, uranium and radon in some deeper wells. However, some shallow wells have also been affected, especially where the local sand and gravel is composed of crystalline rock particles.
3. If you live in a sparsely populated non-agricultural area, and have control over land uses upgradient, or uphill, in the groundwater flow system, installing a shallow well allows you to maximize control of your own drinking water quality. For example, if you have 40 acres of natural forest land, you might be able to install a well with water that is mainly recharged from that non-polluting land use. Remember, however, that you and your well driller must construct your well to certain minimum depths, using the Wisconsin well construction code as your guide.

Driven-point wells can produce high quality drinking water

This publication focuses on well depth and not on well construction. However, people often think of driven-point wells as “shallow” and drilled wells as “deep.” Figure 5 shows two wells at the same depth—one a driven-point or “sandpoint” well; the other a drilled well. Are there important differences between the two?

- A driven well is smaller in diameter (1¼ to 2 inches) than a drilled well (4 to 8 inches). Because of the driven well’s small diameter, the pump is installed outside the well, either in a basement or well house. The external pump adds a potential safety hazard if the underground water line is not installed so that it is under pressure. A buried suction line could allow contaminants to enter the water supply. A drilled well may have a submersible pump—one with the pumping mechanism completely submerged inside the well casing, eliminating this hazard. However, a malfunctioning submersible pump in a drilled well could leak oil used as a lubricant, causing water quality problems.

Figure 5. *Construction differences between driven and drilled wells*



- All driven wells and most drilled wells in sand and gravel have a well screen, the lower slotted section of the casing which allows water to enter. Because driven wells have a smaller diameter (and in some cases, because of differing screen types) their screens may be somewhat more susceptible to plugging from naturally occurring minerals and bacteria.
- Studies conducted at the University of Wisconsin-Stevens Point and the Centers for Disease Control show that coliform bacteria contamination is more common in drilled wells than in driven wells. All the reasons for this difference are not yet clear. However, the caps on many older drilled wells have openings which allow insects to enter, which may introduce bacteria into the wells. Since February 1991, "vermin-proof" well caps have been required for new drilled wells.
- A well drilling license is not required to install a driven well. A person inexperienced in the installation of such wells could make errors that would contribute to future water quality problems.

Although there are differences, it's not true that a drilled well always produces better quality water. A driven well can serve as a safe and adequate water suply.

This information is not intended as a comprehensive evaluation of all the differences between drilled and driven point wells. For a more detailed analysis, refer to the publications listed at the end of this publication, or contact your DNR private water supply specialist.

The well construction report

Your well's construction report contains important information. If it's not currently in your possession, make a point to locate it. If there is a problem with your well water, or if you are concerned about water quality, this information is critical. The well construction report includes information about the:

- Date of well drilling and the property owner at the time
- Distance of structures such as the septic tank from the well at the time of drilling
- Diameter and depth of the hole
- Type of casing and other materials used
- Type and depth of soil and rock formations
- Depth of water table
- Water yield

Since 1936, licensed well drillers have been required to file well construction reports for drilled wells with state agencies.

The Wisconsin Geological and Natural History Survey (address on back page) will attempt to locate the report for you for a small fee. Provide a legal description of your property (town, range, section, quarter-section and quarter-quarter section), and the year the well was installed or the home built, along with the owner's name.

Conclusion

Unfortunately, it is nearly impossible to know the ideal depth of a well before you install it. If you have neighbors, learning the depth of their wells and the corresponding water quality might provide you with some clues. A good rule of thumb for well construction is "as shallow as possible, as deep as necessary," keeping in mind that you must observe the requirements of the well code.

Choosing the "best" well depth is not an easy matter. And, if land uses change, a well that once produced good quality water could become contaminated. However, looking at the direction of groundwater flow, the surrounding land uses, any existing groundwater contamination, and the natural quality of groundwater in the area will all help you to choose a well depth that will provide the best quality water for you and your family.

For more information

Publications from the University of Wisconsin-Extension are available from your county Extension office or from:

Extension Publications
Room 170
640 West Mifflin Street
Madison, WI 53703
(608) 262-3346

Improving Your Drinking Water Quality (G3378). 1986.

Maintaining Your Home Well Water System (G3399). 1987.

Keeping Your Home Water Supply Safe (G3558-1). 1993.

Evaluating the Condition of Your Private Water Supply (G3558-2). 1993.

Interpreting Drinking Water Test Results (G3558-4). 1993.

Choosing a Water Treatment Device (G3558-5). 1993.

Publications from the Wisconsin Department of Natural Resources are available from DNR district offices or at this address:

WDNR
Box 7921
Madison, WI 53707

Well Construction and Pump Installation NR 812 (Wisconsin Administrative Code—State Well Code)

You and Your Well

Driven-Point (Sand-Point) Wells

Well Abandonment

Private Well Construction in Granite Formations

Bacteriological Contamination of Drinking Water

Nitrate in Drinking Water

Pesticides in Drinking Water

Radium in Drinking Water

Lead in Drinking Water

Iron Bacteria Problems in Wells

Sulfur Bacteria Problems in Wells

Volatile Organic Chemicals in Drinking Water

Answers to Your Questions about Groundwater

Radon in Private Well Water

Iron in Drinking Water

The Wisconsin Geological and Natural History Survey is located at:

3817 Mineral Point Road
Madison, WI 53705
(608) 262-1705

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