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College of Agricultural Sciences • Cooperative Extension

School of Forest Resources

Water Facts #5

Water Well Location by Fracture Trace Mapping

A variety of methods are typically used to locate groundwater wells in Pennsylvania. For individual homes, where relatively small amounts of water are needed, wells are usually drilled where a tall drill rig can get access close to the house and far from the home septic system.

In some cases, especially where groundwater yields are low, homeowners and farmers may employ dowsers or water witches to help locate a water well. These individuals slowly traverse likely areas with a forked stick or wire rods until the stick or rod pitches uncontrollably toward the ground, indicating a source of water. Despite numerous studies, no scientific basis has ever been found to support the claims of those espousing this approach.

Where larger amounts of groundwater are needed, such as large homes, farms, or businesses, the client more often trusts the judgment and experience of a reliable well drilling contractor. Experienced drillers develop a skill for recognizing those vegetation and topographic features that indicate better prospects for finding water. This method has a scientific basis in that it recognizes surface features that identify the presence of a zone of fractures in the underlying bedrock and/or the presence of rock types containing adequate amounts of water (Figure 1).

All of these methods of groundwater prospecting have a high likelihood of producing a well with some water. However, if the yield has to sustain a modern home, farming operation, community, or large industrial park, funds are sometimes better spent on a competent hydrogeologist using fracture trace mapping to locate high-yielding wells.

The Fracture Trace Method

Fracture trace mapping has been successfully used throughout Pennsylvania to locate wells that yield millions of gallons of water per day on a sustained basis.

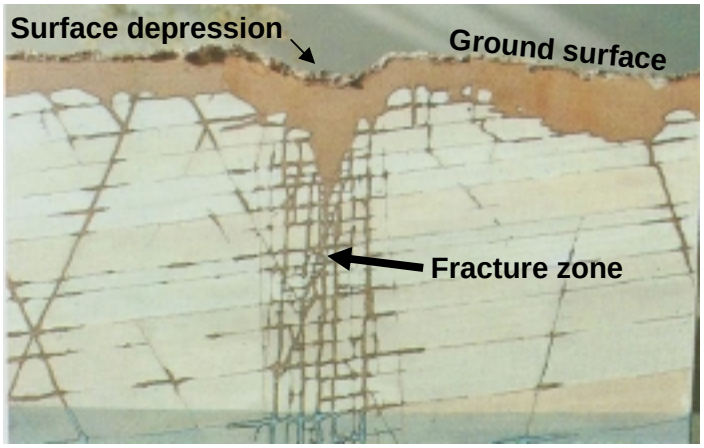

Figure 1. Diagram of a zone of fractures in a cross-section view of limestone bedrock. Notice the surface depressions that often accompany underground fracture zones.

The basis for fracture trace water well location is quite simple. here are zones of structural weakness in the earth's crust that contain zones of fracture concentration in the underlying bedrock. These fractures are actually cracks in the rock that are clustered in zones 5 to 50 feet wide, 100 to 200 feet deep, and several thousand feet to more than a mile in length. Each fracture zone may contain one or as many as 200 separate fractures or cracks and there may be five or ten fractures or zones of fractures in any 100-acre area.

In tightly cemented or dense rock such as limestone, water is found only in the void spaces of these cracks. In other types of rocks, such as sandstones, water can be found in tiny pores in the rock itself, but generally more water can be obtained from fractures. To locate this water, the hydrogeologist must accurately locate and map these zones of fracture concentration, paying particular attention to the specific locations where these fractures intersect. By drilling precisely at this intersection point, the chances of obtaining a good supply of water are greatly increased.

Fracture zones are most easily mapped from readily available aerial photographs (Figure 2). Hydrogeologists study black and white or color photographs for clues to the presence of a zone of fractures underneath the soil. Just as a crack in a plaster wall covered by a thin coat of paint can still be seen, so can fractures under the ground be seen and mapped. The presence of fractures are usually indicated by abrupt changes in the alignment of streams, the presence of taller or more lush vegetation, the alignment of sink holes or other depressions in the surface, or the existence of shallow, longitudinal depressions in the surface overtop of the fracture zone. In addition, the soil in recently plowed fields often dries unevenly, leaving a pattern of dark (wetter) and light (drier) areas. The darker soil areas often indicate depressions over a fracture zone. These features are difficult to distinguish on the ground but they can be identified with a trained eye from photographs.

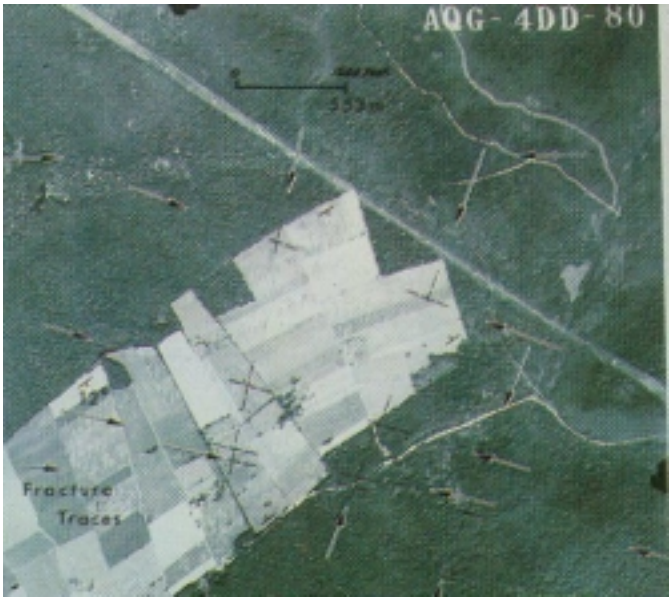

Figure 2. An aerial photograph showing crosshairs where fracture intersections occur.

The accuracy of fracture trace mapping depends on the skills of the person doing the mapping. Those with the most experience can map the most accurately and can map in terrains where surface clues are extremely subtle. A skilled individual can often map fractures on 100 acres of land in just a few minutes.

Once the fractures are mapped on the aerial photograph, the hydrogeologist takes the photo to the field to determine and mark the actual ground location of the fractures for drilling. In heavily forested regions where landmarks are difficult to find, and in rapidly urbanizing areas where the surface landscape has been drastically altered, this is sometimes a difficult task.

During the ground survey, the hydrogeologist also takes note of the rock types found in the area to determine the types of rocks that the driller will encounter. With knowledge of the amount of water that each of these rock types yields, the hydrogeologist can then advise the driller to not waste any time drilling in rock types that contain little or no water. The on-site inspection also reveals the presence of potential pollution sources that could impair the quality of groundwater in the selected area.

Aerial photographs suitable for fracture trace mapping are widely available from a variety of online sources (both free and for a fee). They can also often be borrowed from the local Natural Resources Conservation Service office or county Conservation District office.

Limitations

The fracture trace technique is not without limitations. When surface features have been greatly altered by human-made or natural events, the fracture trace technique usually cannot be applied. In glaciated areas or areas with very deep deposits of unconsolidated materials, the technique can also be difficult or impossible to apply. In areas that have been subjected to extensive urban development, the surface signs of fractures may have been obliterated. Ironically, it is often these very areas that are in the greatest need of additional water supplies. If fractures are mapped and located on the ground in advance of encroaching development, the technique can still be applied and promising well sites can still be located and protected from future development so they are available when needed.

Drillers may also more frequently encounter troublesome problems when drilling on fractures such as cave-ins, mud, or flowing sands. Furthermore, not every fracture trace well is a gusher, so no guarantees for success can be made before starting drilling operations. There may also be a lack of hydrogeologists trained in fracture trace mapping in a given geographic area.

Additional Costs

A well that is located using fracture trace mapping will cost more than a randomly located well because a qualified hydrogeologist must be hired to study aerial photographs and map fractures, determine fracture intersections, and visit the site to mark

drilling locations. This cost could vary from several hundred dollars to a few thousand dollars depending on the time and travel necessary. Of course, this additional cost is often insignificant compared to the total cost for the well. In fact, the fracture trace well may save money in the long run by increasing the chances for adequate water from an individual well.

Applications

In tightly cemented rocks, random drilling often fails to produce enough water to supply the needs of even an individual home. Any water use requiring water yields in excess of average yields for a particular area (Table 1) will in most cases substantially reduce groundwater development costs by applying this technique. Single-family homes rarely need fracture trace wells because small amounts of water, usually less than 6 gallons per minute, are generally needed. This amount of water is found in most randomly located wells, but there are certain localized areas that are notorious for low-yielding wells.

Table 1. The water yield in gallons per minute (gpm) from typical and fracture-trace wells in various geologic formations common to Pennsylvania.

Rock Type	Avg. Yield (gpm)	Yield from Fractures (gpm)
Crystalline (marble, etc)	1–20	200–500
Sandstone, shale	5–60	100–500
Carbonate (limestone, etc.)	5–500	500–3,000
Unconsolidated (gravel, sand)	100–1,000	Not applicable

Fracture-trace location of wells is much more useful, however, for farms, businesses, or communities that need much larger producing wells. It has a high probability of exceeding the average yield in a given area and, therefore, meeting water use demands. For example, one past survey of 123 communities that had wells located using fracture trace mapping found that 80 percent exceeded the average yield of groundwater aquifers in their regions. In many cases, the well yield obtained far exceeded any previously obtained well yields in that region.

Land use planners in growing communities may also find fracture trace mapping a valuable tool for protection of future water supplies. Activities with the potential to pollute groundwater resources, such as mining, landfills, or industrial parks, can be located to avoid zones of fracture concentrations.

Figure 3. A well (arrow) located in a depression that was mapped using the fracture trace method for a farm in central Pennsylvania.

Finding a Hydrogeologist

The first step in having a well location mapped using the fracture trace method is to find a qualified hydrogeologist. Professional hydrogeologists are often listed in the yellow pages of your local phone book under “Geologists.” You can also contact local water well drillers, Department of Environmental Protection offices, Conservation Districts, or Penn State Cooperative Extension offices to find names and contact information for local hydrogeologists.

A Final Word

Fracture trace mapping has been used for decades to successfully locate high-yielding wells. Consider utilizing this technology if you are in need of a larger-than-average producing well for a home, farm or business.

Additional Resources

For further information on management of wells and springs in Pennsylvania, visit our Web page at:

www.sfr.cas.psu.edu/water

or contact your local cooperative extension office. More details on water system planning and sizing can be found in *Private Water Systems Handbook* (MWPS-14), which can be ordered for $7 from the Natural Resource, Agriculture and Engineering Service at www.nraes.org or 607-255-7654.

Prepared by Bryan R. Swistock, extension associate, and William E. Sharpe, professor of forest hydrology.

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