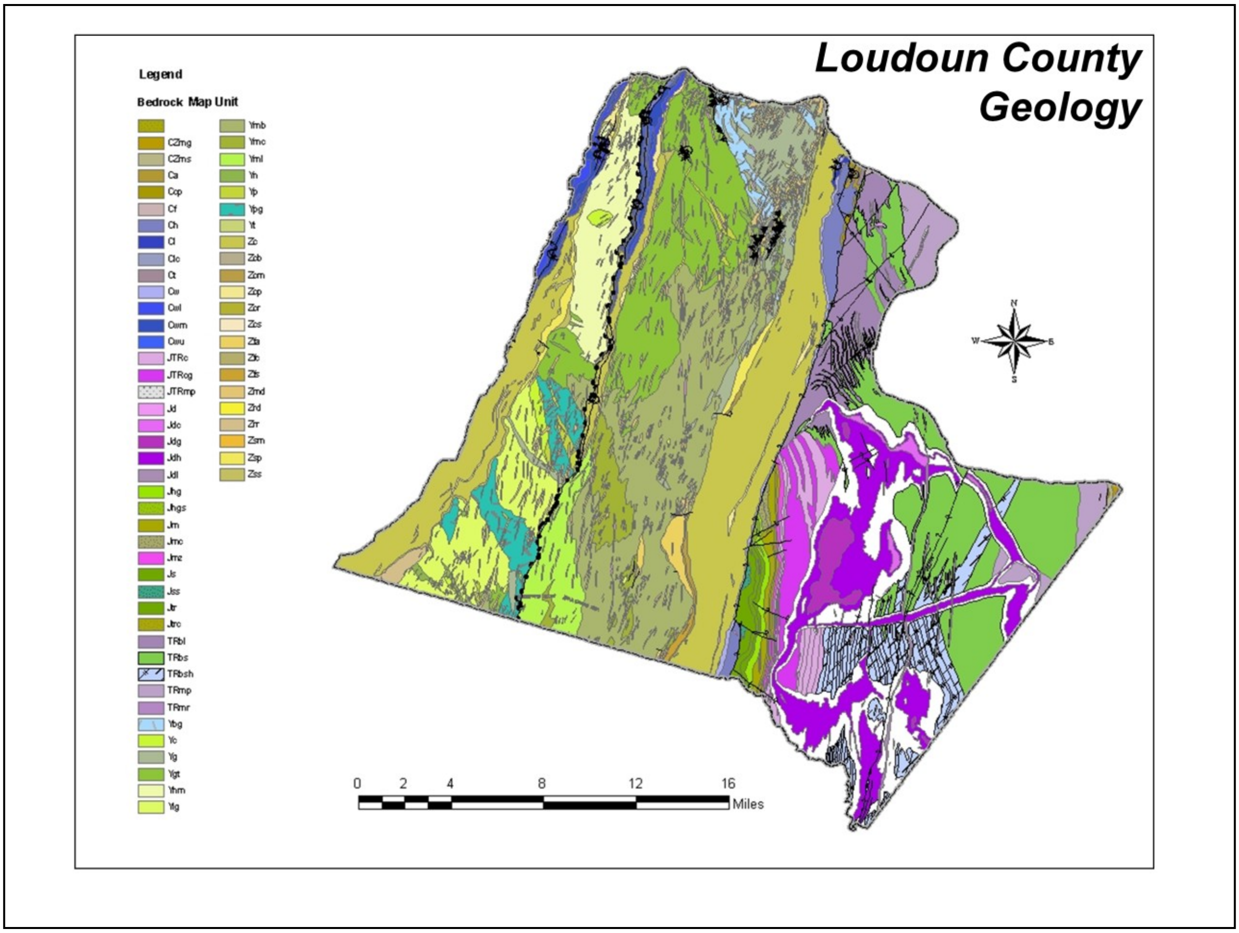
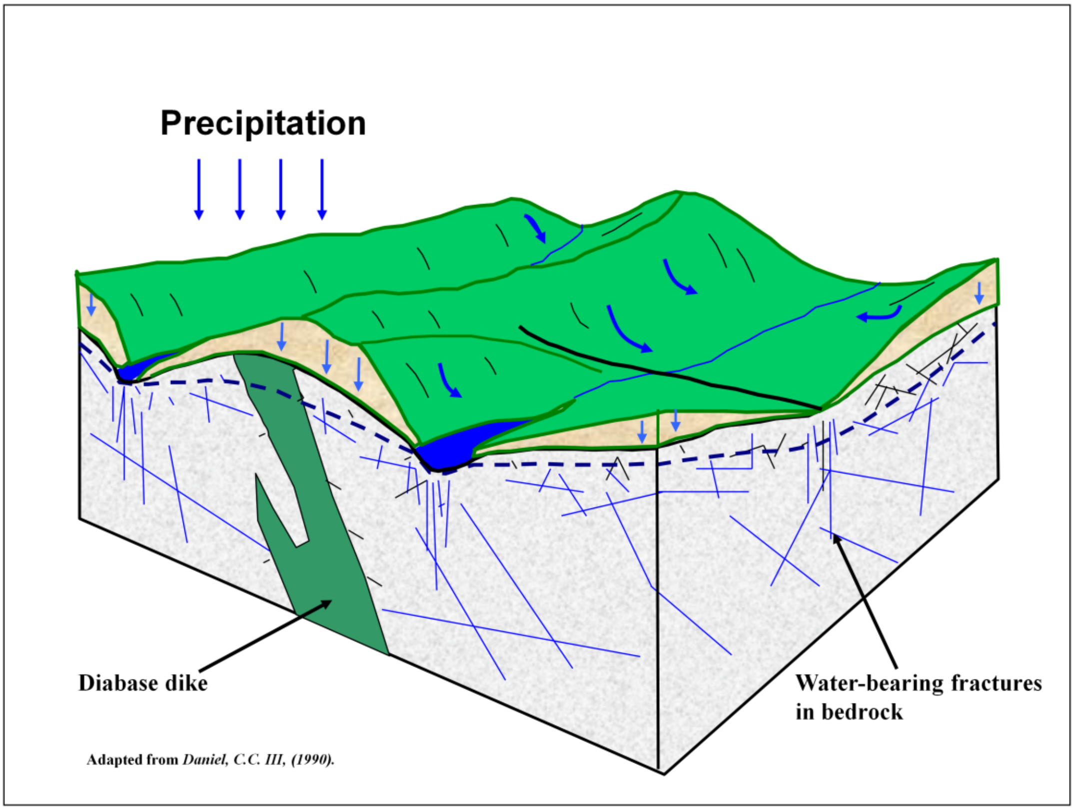
Groundwater Basics In

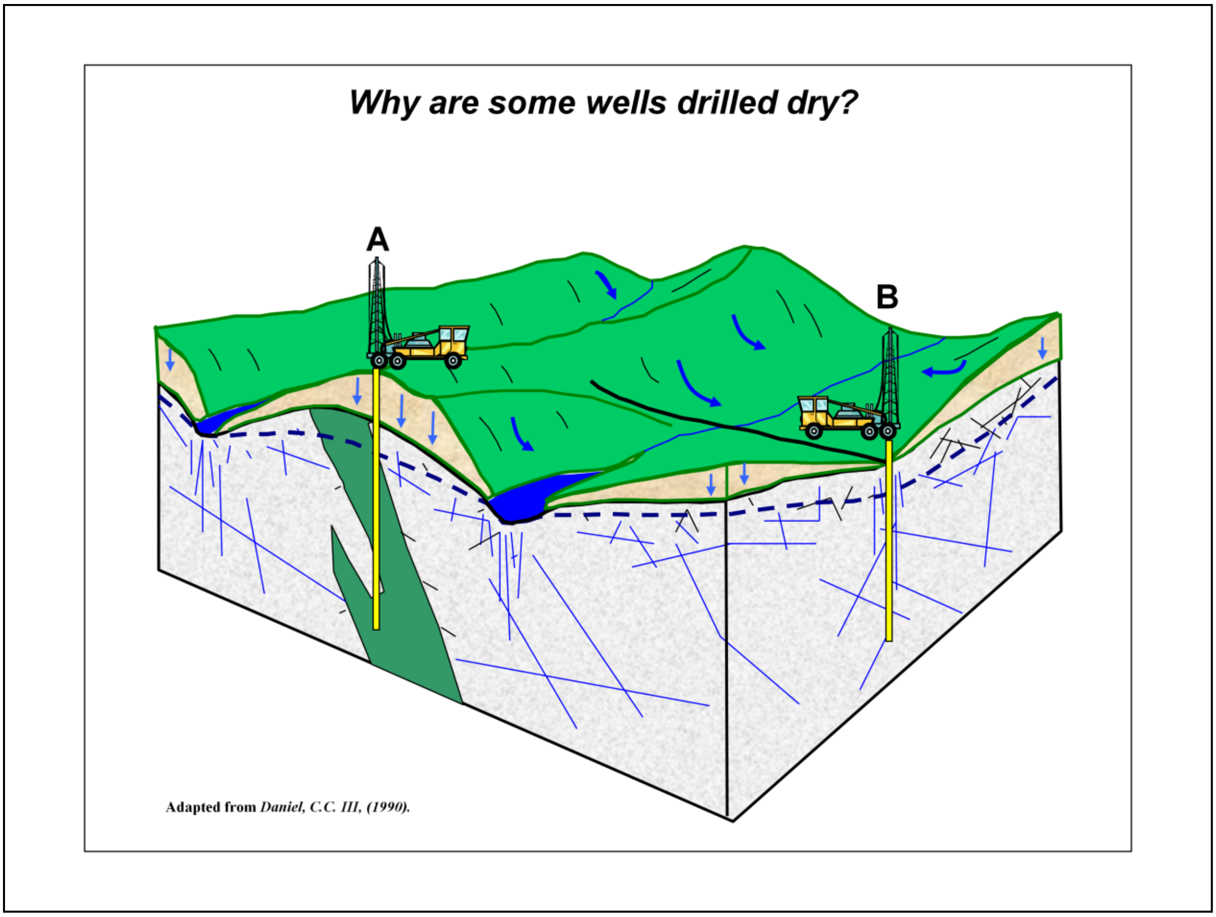
Loudoun County, VA



The geology of Loudoun County is very complex, with over 60 different rock units, cut by faults, shear zones, and igneous intrusions. Western Loudoun consists of older, metamorphic rocks and granites, separated from the younger Culpepper Basin rocks in Eastern Loudoun by the Bull Run Fault, which roughly parallels Highway 15. The type of bedrock into which a well is drilled can affect the probability that the well will yield adequate water. Soil and weathered rock cover the bedrock at thicknesses typically ranging from a few feet to 30 to 50 feet.

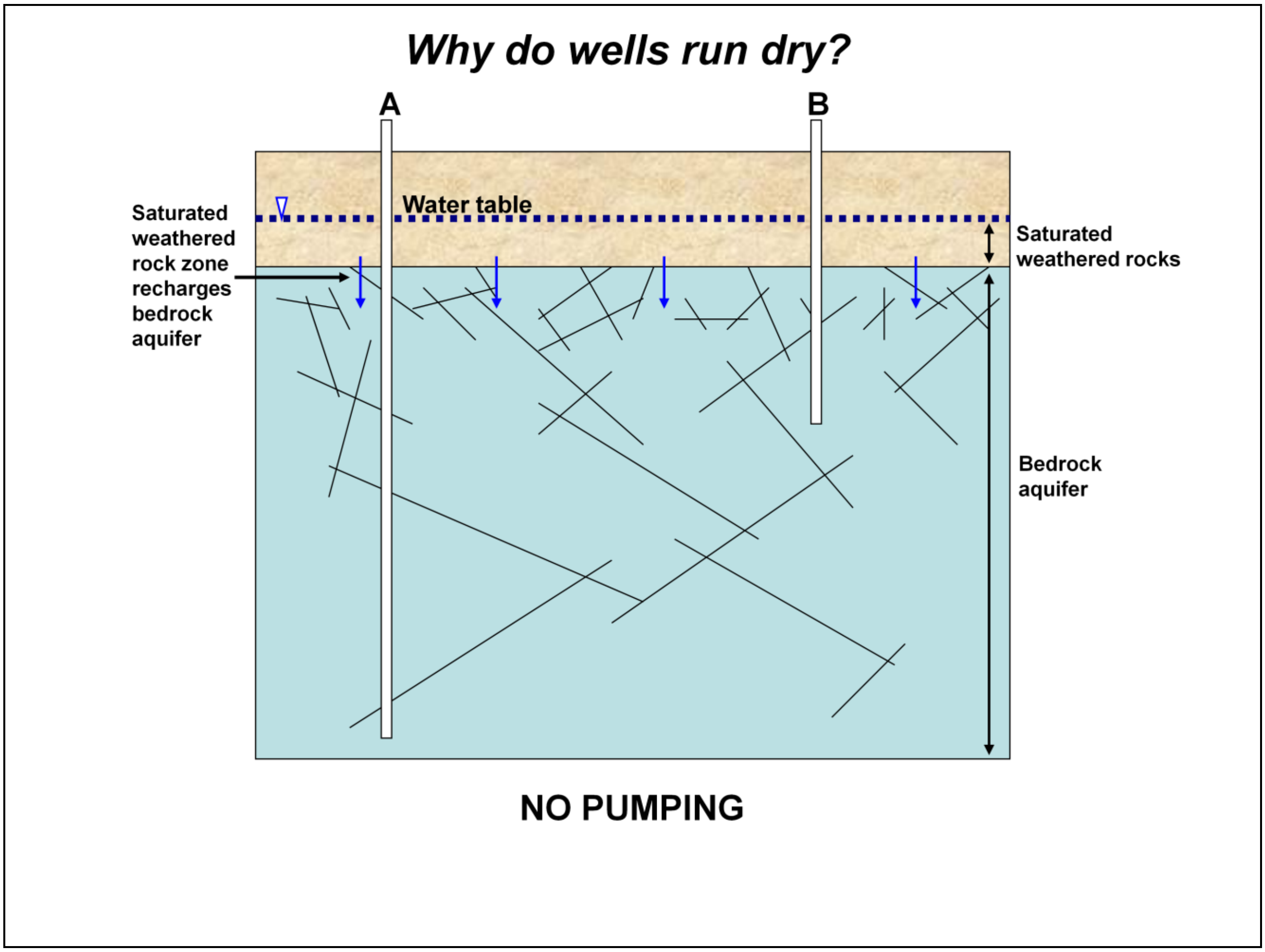


Precipitation falling on the land either evapotranspires (returns to the atmosphere), runs off as overland flow, or infiltrates into the soil. At some depth (typically 10 to 30 feet below land surface in Loudoun), all of the open spaces within the soil or rock material are saturated with groundwater - the top of this surface is called the water table. Where saturated rock can provide useful amounts of water, it is called an "aquifer". In the underlying bedrock, the groundwater occurs and moves primarily in fractures within the rock. Some groundwater is returned to surface water as baseflow discharge to streams. Variations in bedrock type and structure affect the occurrence and movement of groundwater and, as in the example above, a diabase dike with no fractures can impede groundwater flow.



Throughout Loudoun County, water wells are drilled into bedrock and must encounter water-filled and interconnected fractures, pores, or cavities in the rock to yield water. The size and density of the pores and fractures vary with rock type, depth, and location.

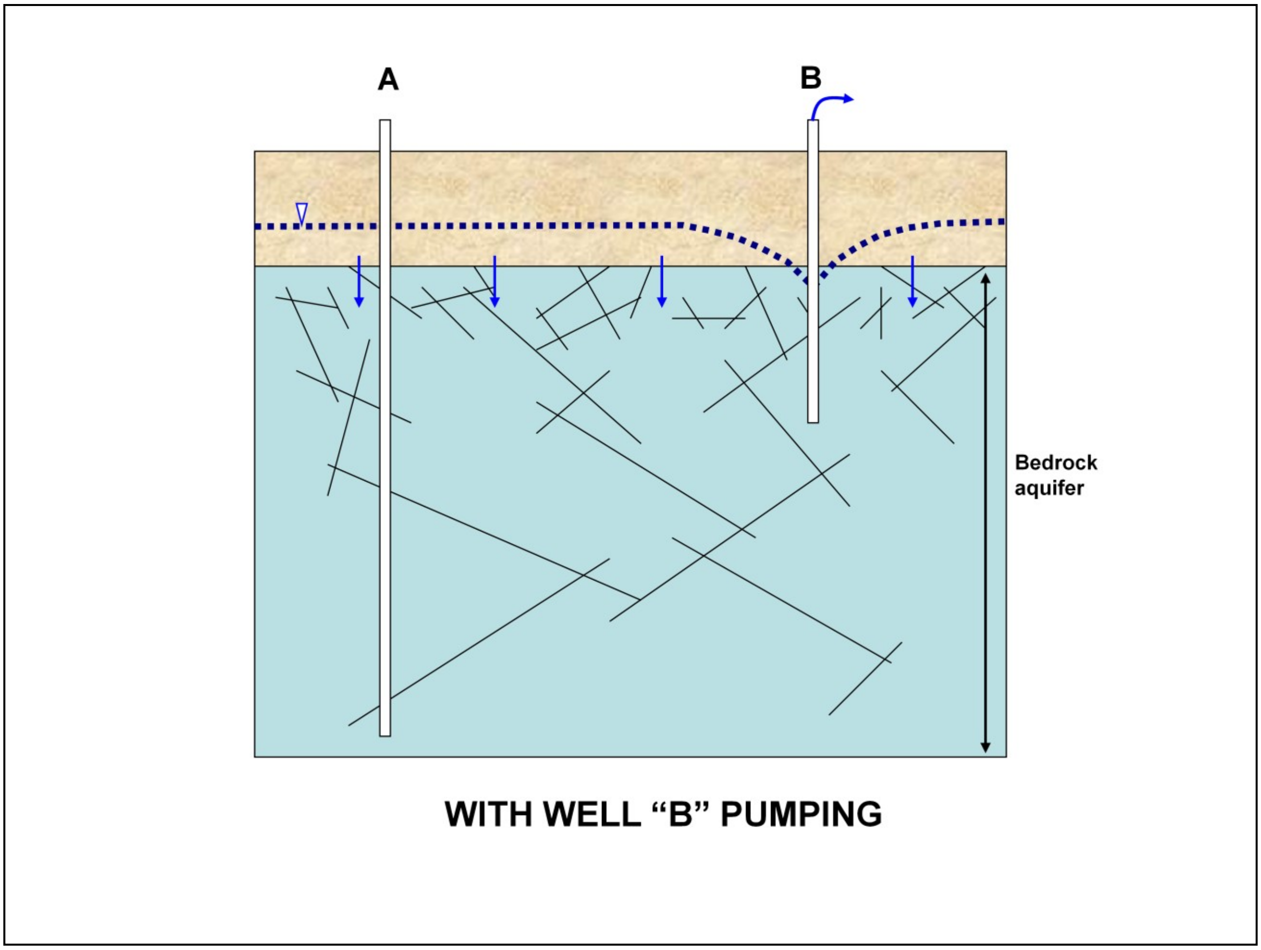
In the figure above, well "A" is drilled into diabase rock. Diabase rock has fewer and smaller fractures and less porosity through which groundwater can move than does the surrounding rock. In this example, well "A" does not encounter water-bearing fractures, and therefore, yields no water. On the other hand, well "B" is drilled into a rock type that has more fractures. In this example, well "B" encounters multiple water-bearing fractures and, therefore, yields water.



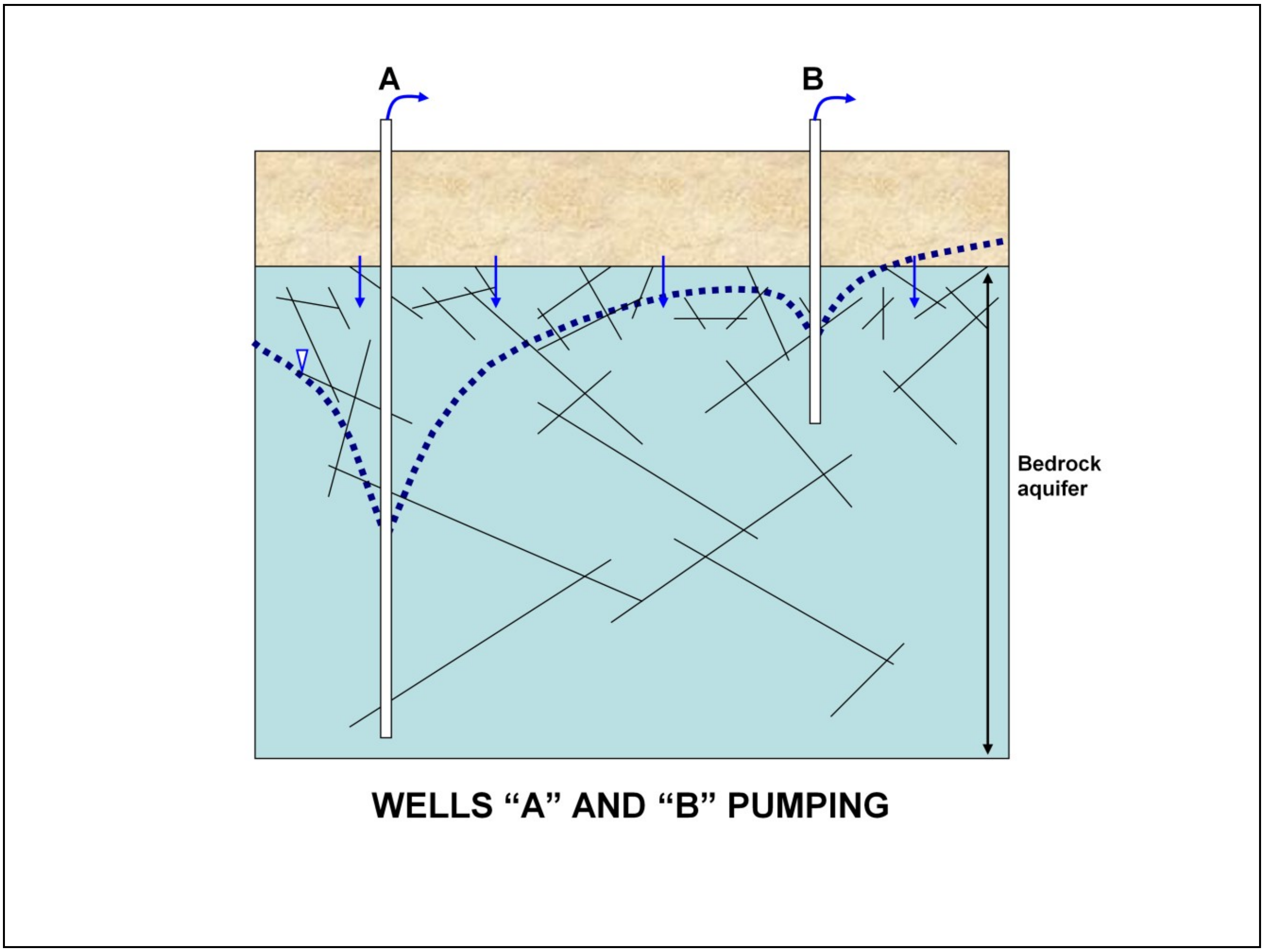
In many areas of the county, much of the available water is stored in saturated soil and weathered rocks located near the surface, with less amounts stored in the small fractures of the underlying crystalline bedrock. However, for contamination prevention, all newer wells are cased through the upper layer and receive water only from the lower bedrock. Therefore, successful well drilling depends on encountering water-bearing fractures in the bedrock.

In the figure above, well "A" is a deep well encountering four fractures zones with three of them relatively deep. Well "B" is a shallower well (as are most older wells) and encounters only one fracture zone which is relatively shallow.

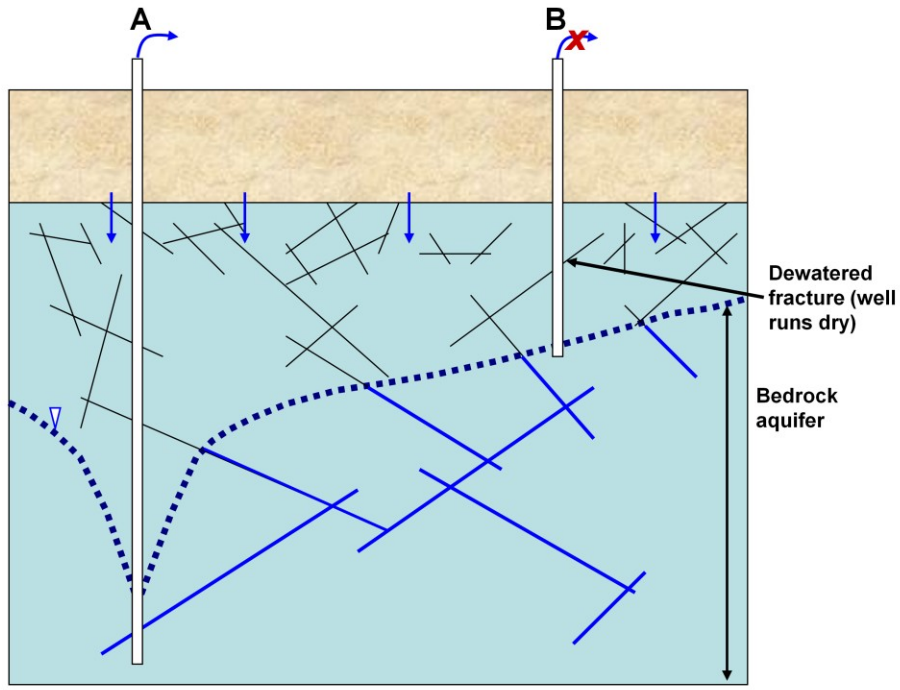
This view shows the water table with no pumping of either well.



With well "B" pumping, a cone of depression develops in the water table around the well as water is removed from the aquifer by the well. (The size and shape of this cone of depression depends on many factors and here is simplified for illustrative purposes.)



When well "A" begins pumping, a cone of depression develops around it also. The cumulative effect of both wells pumping causes the water table to drop further. If the wells are close (and depending on other conditions), the cone of depression from one well may affect the water level in another well.



WELLS “A” AND “B” PUMPING

With continued pumping of both wells, the water table continues to drop, and the one fracture zone feeding well “B” is dewatered, causing that well to go dry.

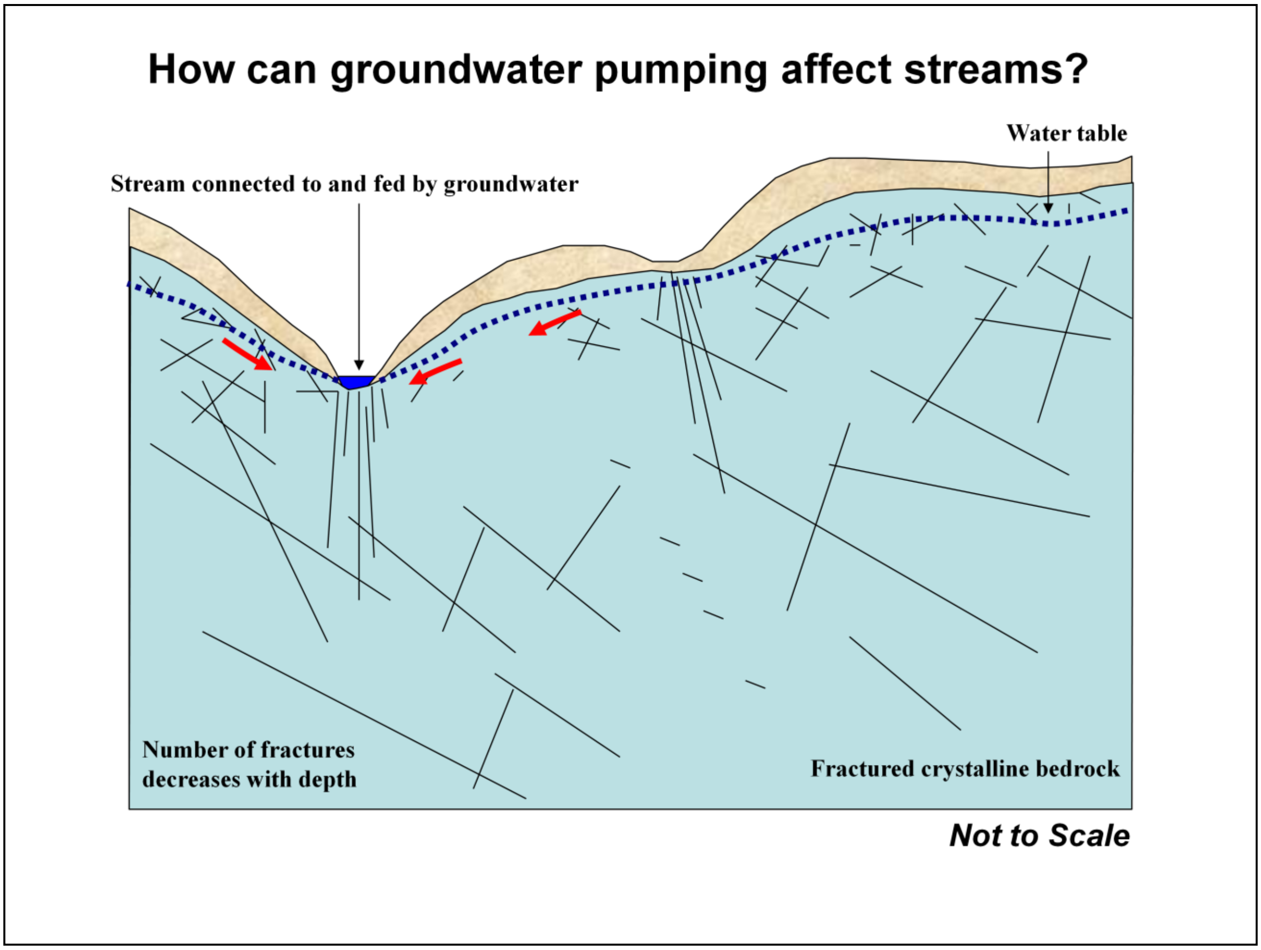
In this example, deepening of well “B” would encounter additional water bearing fractures that may be “safe” from dewatering.

Other reasons a good well "runs dry":

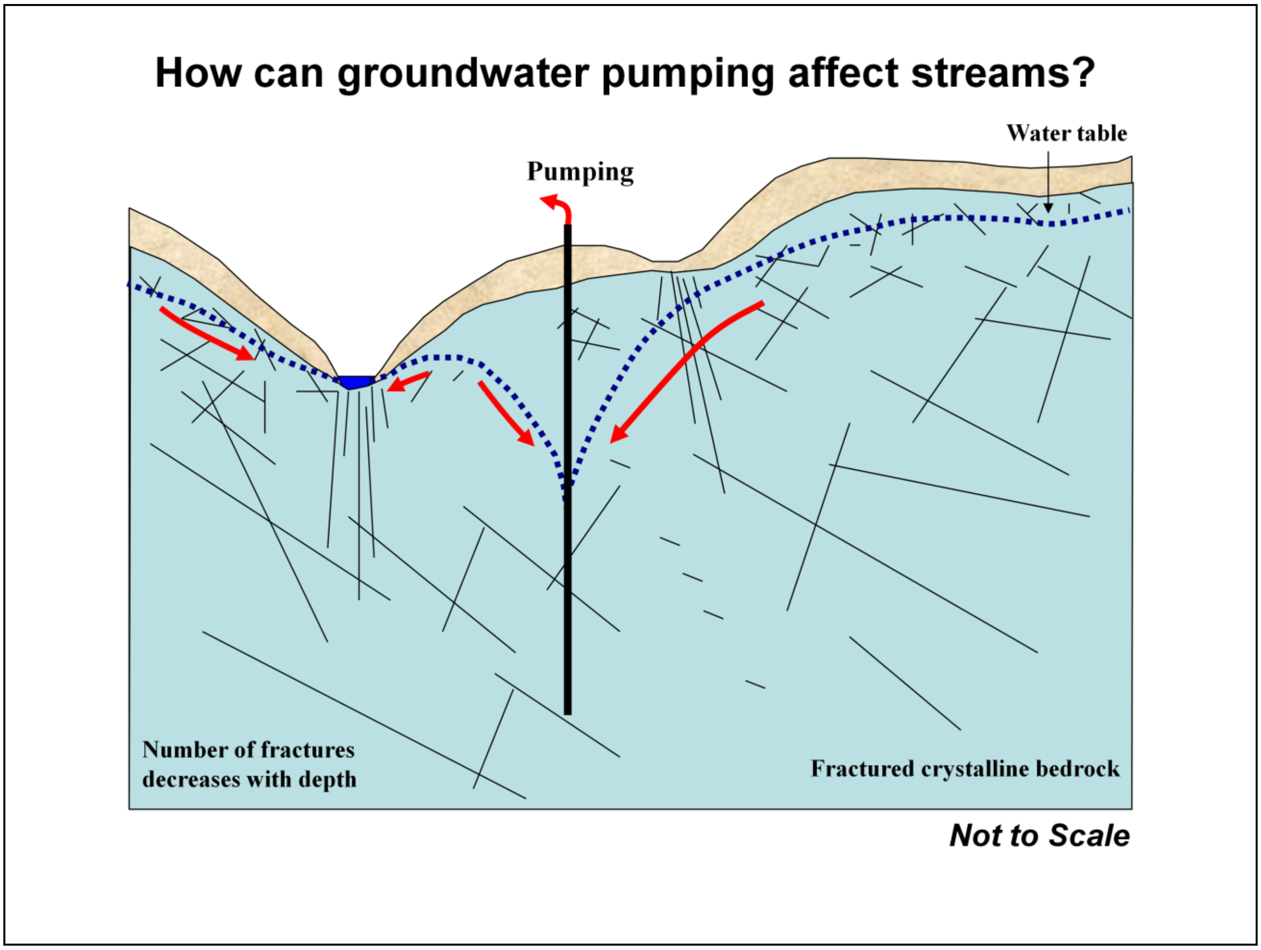
- ***Biofouling*** **– A buildup of naturally occurring bacteria around well casing, borehole walls and pump intake can cause a well to underperform. The well can be rehabilitated.**

- ***Sedimentation*** **– Excessive deposits of sediment may fill water-bearing fractures, lowering production.**

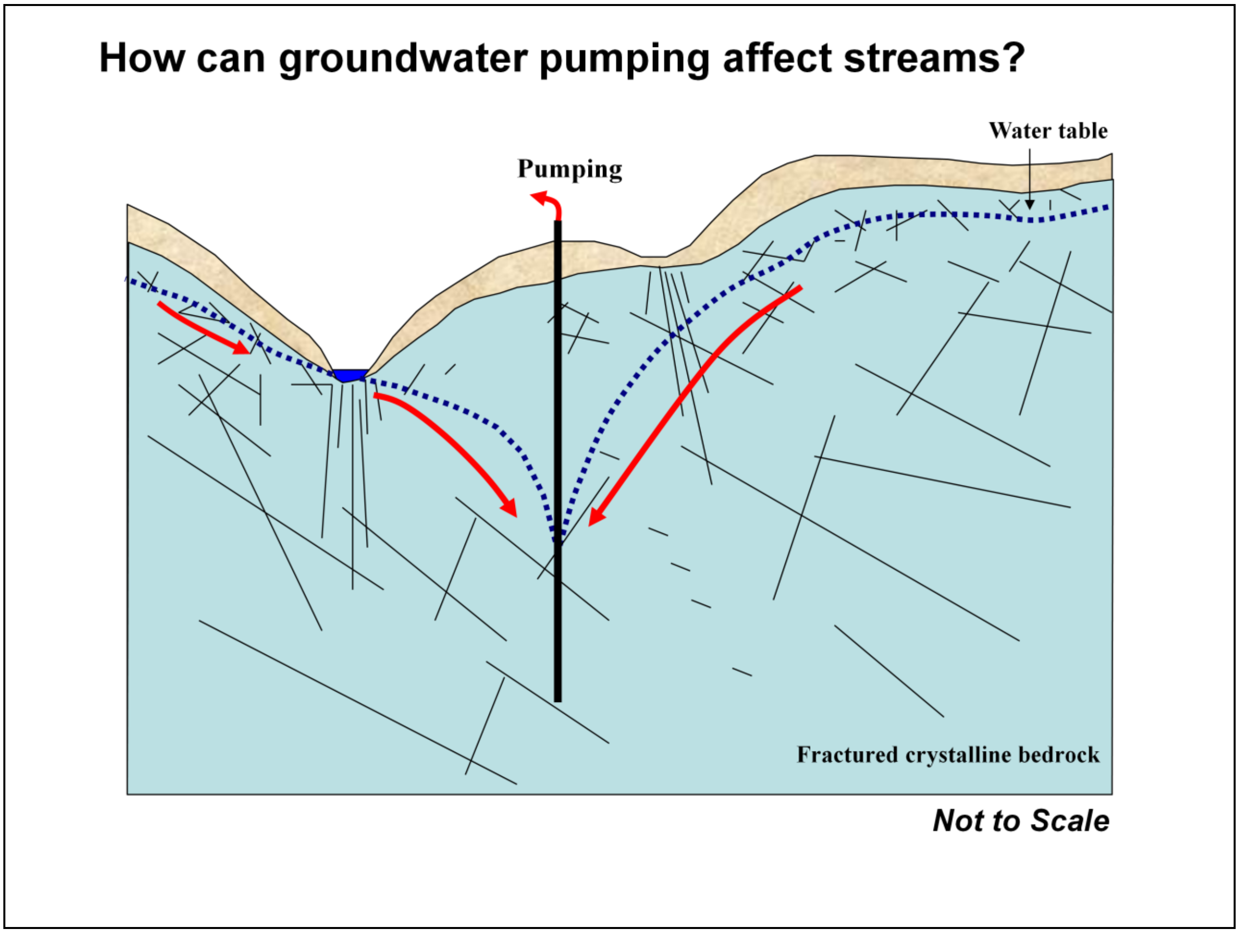
- ***Pump failure.***



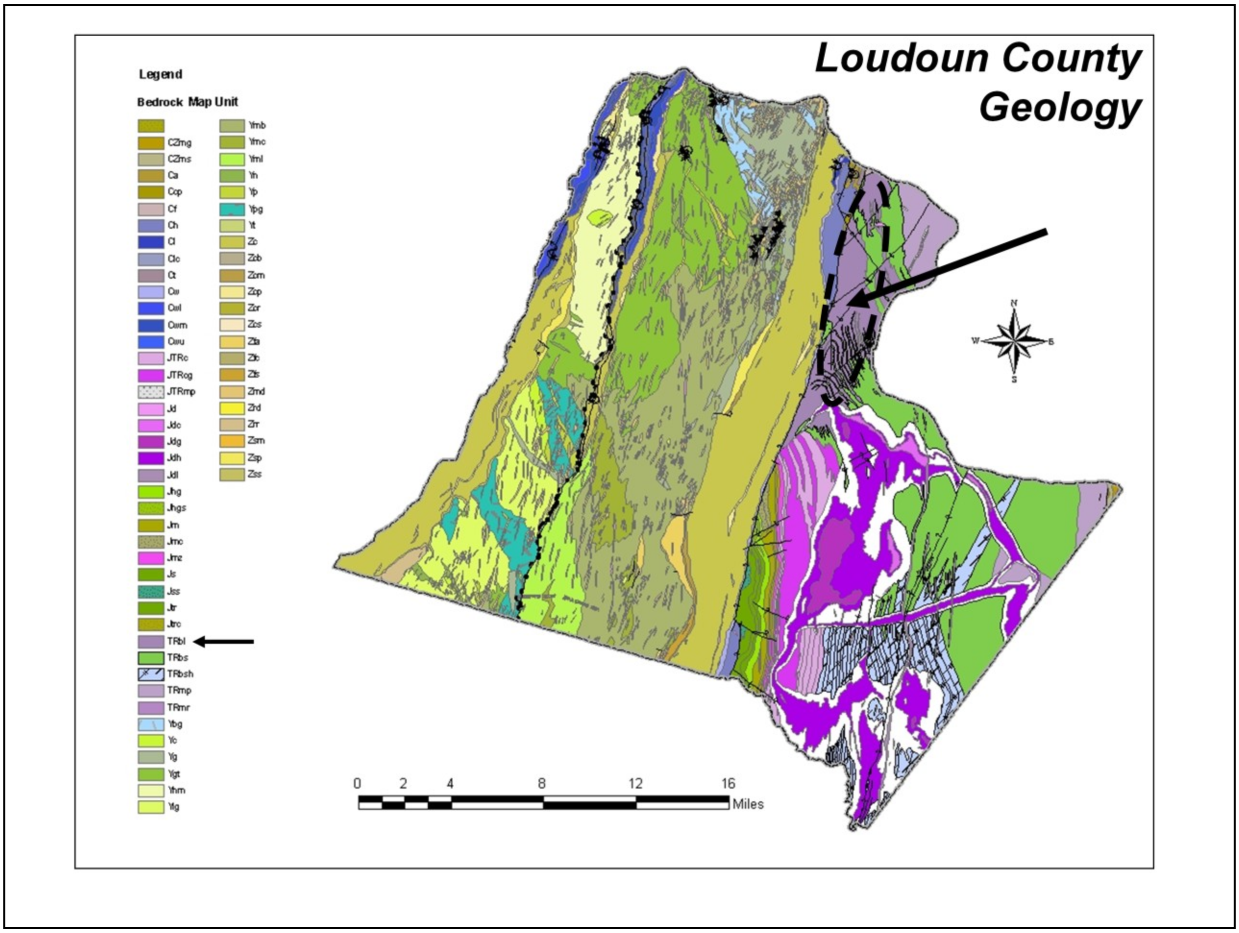
Under normal conditions, groundwater flows to streams providing most of the stream’s water between rain events. This is called “baseflow”.



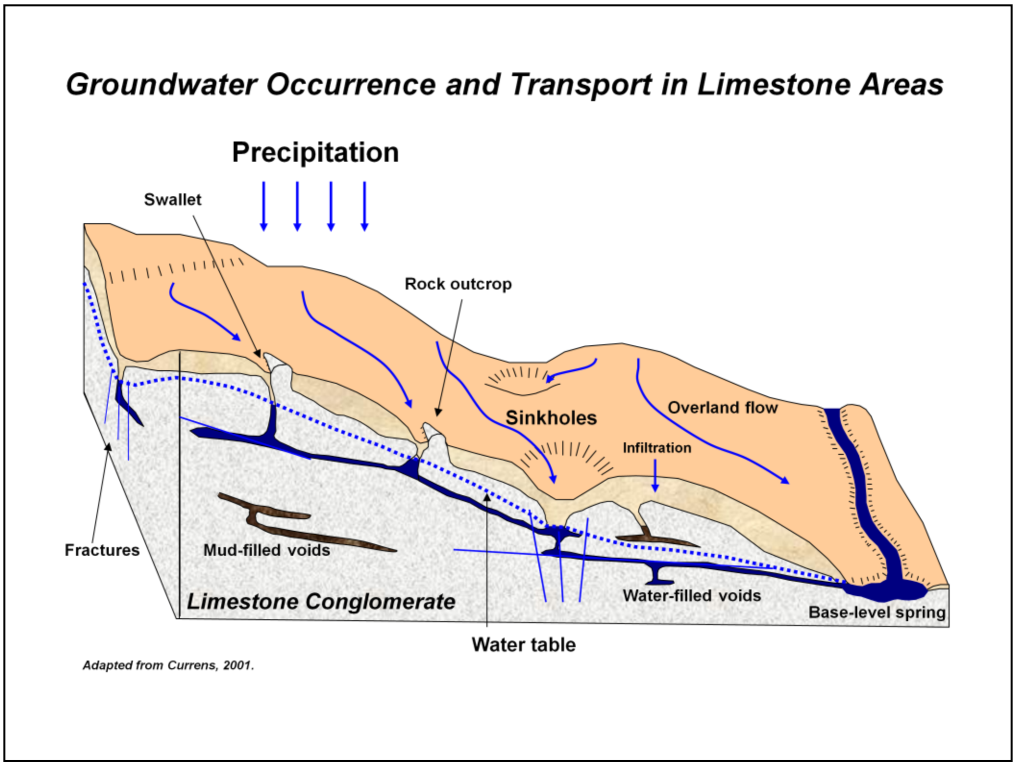
When a well is pumped, water flows into the well and the groundwater near the well is lowered, forming a "cone of depression". This changes the gradient of the water table and , as depicted on the left side of the well above, reverses the direction of groundwater flow near the well.



Continued pumping may expand the cone of depression around the well. In this example, it has led to a reversal of the hydraulic gradient between the stream and the well. Now the stream has lost some of its normal baseflow and is losing water to the groundwater system. Reduced baseflow, particularly during periods of drought, affects stream health.



Location of Limestone Conglomerate area prone to karst features in Loudoun County - - generally from Leesburg north,and east of the Bull Run Fault.



Conceptual Model for Limestone Conglomerate Area

Subsurface flow is dominated by conduits formed by the dissolution of limestone conglomerate by water. Where below the water table, these voids may be filled with water, but are often filled with mud.

Precipitation may infiltrate through soil into underground conduits, or may flow directly into subsurface through swallets and sinkholes. This allows for very rapid transport of water and any contaminants on the surface. Water re-emerges as springs or baseflow to streams.

As water dissolves limestone and voids are created, the soil above the sinkhole may be the only support for surface features. When the remaining soil layer is too thin to support the surface, the soil collapses, and a sinkhole is formed, with potentially catastrophic results.

Any event that causes fluctuations in water level (drought, heavy rainfall, pumping) can accelerate the formation of sinkholes by washing out mud-filled voids, dewatering water-filled cavities, and saturating soil "ceilings" overlying shallow underground cavities.