Let's Talk Water – Ground Water Flow

By Dr. Mike Strobel

Ground water occurrence and movement are concepts many people don't understand. For centuries, ground water has been a mystery because it was under the ground and out of sight. Many people use to think of it as magical because of the way water disappeared into the ground (infiltration) and appeared again on the land surface (springs).People created stories of great underground rivers and lakes and other colorful concepts for ground water. I guess we often use stories to explain what we don't understand, but ground-water flow really is a simple concept.

In most cases, ground water occurs in the pore spaces in rocks and sediments. We discussed porosity in an earlier column. Some water gets into the pores as recharge, where the water on the land surface (rainfall, snowmelt, rivers, etc.) seeps into the ground and moves to the water table. In some cases, especially in really deep aquifers, the water can be what we call connate, which means the water has been there since the rocks or sediments were deposited. Most sedimentary rocks are formed in water environments, whether its sediments deposited at the bottom of an ocean, river sediments, lake sediments, or even alluvial fans. As these sediments are deposited, water gets trapped in the pore spaces and can stay there for very long periods of time. However, most water in aquifers we use tends to be close to land surface and relatively recent recharge.

Once in the ground, water moves from pore space to pore space. The movement can be really slow in rocks and sediments that are fine grained, such as in clays and silts. The movement can be pretty fast in gravels and other coarse materials. You can observe how water moves through sediments by filling a glass jar with sand and then pouring water into the jar. The water will move between the grains and slowly move downward because of gravity. This movement from pore space to pore space is how ground water flows.

In cases where there are cracks and fractures in the rocks, water can move through these much quicker than it can through the solid rock. You can think of the cracks and fractures as huge pores that water can fill and move through with little resistance. These are sort of like ground water superhighways. Many well drillers putting in wells in bedrock areas hope to encounter cracks and fractures because these can greatly increase the rate of water flow going to the well. I know of some areas in the country where drillers actually use high pressure (called hydro-fracturing) to rupture the rocks deep in the ground in order to increase ground-water flow to wells. Cracks and fractures can greatly enhance the rate of ground-water flow as compared to the movement between pre spaces.

Ground water in unconfined aquifers moves due to gravity. So, one can see that ground water will move from higher elevations to lower elevations. This is how water that enters the ground in the mountains ends up in the basins in eastern Nevada. It is also how water moves across a basin and from one basin to another. Gravity is the driving force in such cases. Scientists will measure water levels in a number of wells in a basin in order to get a good understanding of the directions of ground-water movement across the basin.

In deep confined aquifers, gravity is not as important as pressure. Remember the first Let's Talk Water article where we talked about confined and unconfined aquifers, it was mentioned that confined aquifers are geologic units filled with water and confined both above and below by confining units (such as shale or clays). Think of a confined aquifer like a large bladder or water bed, where the water is held by the surrounding less-permeable units. On a bladder or water bed, if you pressed on one corner, the water would tend to move towards the other side and bulge up. This is similar to a confined aquifer. Ground water in a confined aquifer moves because of pressure and will flow from a point of higher pressure to lower pressure. Pressures in confined aquifers are often caused by the weight of the overlying rocks and sediments. So, ground-water flow in a confined aquifer may be in a different direction than the ground-water flow in the overlying unconfined aquifer simply because they are driven by different forces (gravity verses pressure).

I mentioned in the beginning of this article that people created stories about underground rivers and lakes. In the vast majority of settings (probably more than 99.9 percent of times) ground water occurs only in pore spaces and in small cracks and fractures. However, in special settings when there is limestone and dolomite as the bedrock, caverns can occur. Because many people have been into caves and seen ground water in some of the caverns, stories of huge underground river and lakes have been used to describe ground-water occurrence and flow. Keep in mind that this is the exception and not the rule for most places. I have heard stories of a huge underground lake that extends from South Dakota and Nebraska all the way to Texas and New Mexico. In reality, this is the High Plains aquifer and it's a large sand unit that extends along the front range of the Rocky Mountains. It's a huge, continuous aquifer and the water occurs in the pore spaces between the sand grains. Its well studied and understood, but people still tend to use stories about this great underground lake.

If you have questions about ground-water flow, please write to me in care of the Ely Times or email me at mstrobel@usgs.gov. Next week, we will discuss water quality.