GROUND-WATER RESOURCES OF THE COWPASTURE RIVER VALLEY

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Editor's note: The following essay is the third in a five-year series on water resources stewardship in the Cowpasture River Watershed, sponsored by the Cowpasture River Preservation Association and published by The Recorder. The goal of the series is to create awareness among students, citizens and officials of the critical need to protect our surface and ground-water resources, and to stimulate interest in progressive stewardship.

Ground Water – Water that is stored and moves through underground reservoirs is called *ground water.* Water moves from the surface to recharge the subsurface reservoirs and ultimately returns to the surface at springs and seeps to maintain the flow of streams between storm events. The time from when water from rainfall percolates into the ground and returns to the surface in stream valleys is termed *residence time*. The residence time may be hundreds to thousands of years depending on the permeability of the underlying rock formations. The interchange between surface and ground waters may happen much faster in areas of limestone karst where much of the flow is through open conduits (caves) and the residence time may be a matter of hours or days.

Hydrologic Cycle – All of the water flowing through the Cowpasture River drainage basin originates from precipitation. Average annual rainfall in the basin is about 40 inches and a little over half of this returns to the atmosphere through evaporation and transpiration by plants. The yearly flow or *runoff* for the Bullpasture River at Williamsville is about 19 inches and about 16 inches for the Cowpasture River at Clifton Forge (data from the US Geological Survey). Runoff includes surface-water flows generated by storm events and ground-water discharge to the rivers that occurs year round. During drier periods all of the water flowing in the river comes from ground water and 60 to 85 percent of the annual runoff is from ground water. The partitioning of the total precipitation into the different categories (evaporation, surface runoff, ground-water runoff) gives us a *water budget* for the drainage basin.

Aquifers – Precipitation that infiltrates through the soil and surface waters that sink become ground water. Ground water flows though pores, fractures, and sometimes caves in the underlying rock formations. *Aquifers* are ground-water reservoirs that store and transmit ground water. The top of the saturated zone of an aquifer is called the *water table*. The water table is at or sometimes just below the level of the stream channels in the valleys and rises under the higher ridges. Ground water flows down the gradient or slope of the water table toward seeps and springs at or near river level. The rate of water movement is a function of the steepness of the gradient and the size and connectivity of the openings in the rock. Ground water may only move a few inches per year in shale and over a mile per day in karst conduits. The principle aquifers in the Cowpasture River basin are Silurian and Devonian age shale and limestone. The black shale seen throughout the Cowpasture River valley is the Devonian Millboro (Marcellus) shale.

Geologic Structure – The rocks in the Cowpasture River basin are highly fractured from the mountain building processes that created the folds and faults characteristic of the Valley and Ridge of Virginia. The ridges and stream valleys are oriented in a northeast – southwest trend and the pattern of the streams when seen on a map is one of steams flowing parallel to each other until one can break through a water gap such as the Bullpasture Gorge above Williamsville. This NE-SW pattern is aligned along the direction of the folding of the rocks, and fractures in the rock often follow this direction along with the contact between different geologic formations. Ground-water flow is often concentrated in fracture zones, so predicting the location and trend of these zones is an important tool for picking the drilling location for water wells.

Karst – Karst landforms develop on soluble rocks (limestone in the Cowpasture River basin) and the interplay between surface and ground water is relatively fast. Limestones are exposed at the surface over about 15 percent of the total area of the Cowpasture River basin but are the most important ground-water aquifers in terms of flow volume. Water enters the karst aquifers by percolation through sinkholes, infiltration through the channels of *losing surface streams*, and direct capture of surface streams at sinks or *blind valleys*. Most of this water flows underground through caves (pipe flow) and resurges at large springs along the rivers. Karst features are especially well exposed in the Burnsville area with numerous sinkholes, caves, and dry valleys. Most of the sinkholes we see in the karst of this region are formed by dissolution at the surface and are not due to collapse of underground voids. The community of Burnsville sits in a coalescing chain of sinkholes called an *uvala*. Much of the flow at Coursey Spring is actually the return of surface water captured from water sinking in the bed of the Cowpasture River several miles upstream of Williamsville. Karst waters are especially vulnerable to contamination because of the rapid flow rates and the direct connections to surface runoff. The direction of movement of karst waters is difficult to predict and the underground flow paths sometimes cross under mountain ridges to emerge in a different drainage basin. Nevin Davis and Phil Lucas of Burnsville have conducted numerous water-tracing tests starting in 1969 to study the movement of karst ground water in this area. The water from several of the sinks and caves was found to cross underneath the channels of the Bullpastue and Cowpasture Rivers and reemerge at springs on the far side of the rivers. The headwaters of Dry Run west of Burnsville sink in the Cowpasture drainage basin and resurge on Muddy Run in the Jackson River Basin.

Contamination of ground water – The water quality in the Cowpasture River basin is very good overall. Ground water, especially in the karst areas, may be contaminated by substances applied or spread on the land surface. Sinkholes are essentially natural *injection wells*, so anything dumped in a sinkhole has the potential to contaminate a spring some miles away. The old practice of using sinkholes as garbage dumps or for disposal of dead animals should never be allowed.

The ground and surface water resources of the Cowpasture River basin should remain exceptionally pristine, so long as the landowners and visitors continue responsible stewardship of these wonderful waterways.

A fluorescent tracer dye is being added to a sinking stream in the Bullpasture River drainage to determine where the water returns to the surface and the travel time for the tracer.

The junction of the Bullpasture (left) and Cowpasture (right) Rivers at Williamsville pictured during low flow. All of the water is from ground-water discharge to the streams and there is no water in the surface channel of the Cowpasture River for several miles upstream.

Internet Research URLs:

www.dmme.virginia.gov/dgmr/divisiongeologymineralresources.shtml
Information on Virginia Geology

www.karstwaters.org
Information about karst and a karst dictionary

http://waterdata.usgs.gov/nwis/rt
Flow (discharge) data for the Bullpasture River at Williamsville and the Cowpasture River near Clifton Forge

http://pubs.usgs.gov/of/2014/1156/
USGS Karst Map

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