A Good Vein

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My mother could not stand dust in the house. Unfortunately, the log cabin that she and Dad built themselves in the late 1940s was along an often-used dirt road. The cabin was mom's first and only home after marrying Dad, the place where she lived for the next 65 years. She wouldn't count as home the six months in assisted living at the end of her life nor the time living with her in-laws while work on the cabin began. Dad's parents lived a mile or so up Easley Road from the cabin site. Grandma Easley talked constantly, revelled in the illustrious past of *her people,* and disparaged the Easley clan into which she'd married. Mom found grandma's constant gossip and judgements grating and was glad to move to the small cabin despite its having no running water nor toilet. A nearby spring and outhouse met their needs initially. However, after Dad grew tired of carrying buckets of water up the hill to the cabin from the spring below, he decided to dig a well.

Dad was not well-educated, neither in school nor through personal reading. He was good with his hands, and that kept our family comfortable. As he began the process of digging a well, I think he had in mind some underground network of natural pipes or maybe something more organic—a kind of Mother-Earth circulatory system. If he could just tap into it, he'd have an abundant water supply. His view is not quite as ignorant as it sounds when I write it—the heavily weathered rock beneath our home had relatively low permeability, but the underlying fractures collected and transported much of the water.

Dad began hand-digging wells within sight of the cabin's front door. He seems to have had no rhyme or reason for placing them except seeking to bump into, in his words, "a good vein of water." His first two attempts bottomed out on solid bedrock while yielding no significant water. When the third well once again struck bedrock, Dad tried a new approach. He put half a stick of dynamite down the hole to open up the bottom. Not much effect. So he put *several* sticks of dynamite down the hole. According to Mom, the blast threw rocks over the rooftop of the nearby house. Dad was ahead of his time—he fracked the low-permeability rock! The resulting reservoir at the bottom of the well was about eight feet in diameter and about the same depth. Above it was the five-foot-diameter shaft that Dad had dug, with a total depth of about 35 feet. Across the middle of the reservoir, Dad installed a horizontal pipe so that if any of us kids fell in, we'd have something to hang onto. However, as some of my students like to point out, if we'd fallen in, the pipe would probably have

broken or broken us.

Until the summer after Dad died, the well top was covered with a wooden box, five feet on a side and about four feet high, that had an opening in top to allow a bucket to pass through. Covering the whole thing was a gazebo with four corner posts, a shingled roof above, and a wind vane on top. A rope connected the bucket to a pulley in the top of the gazebo and then to a windlass—a round log around which the rope wrapped and through which passed an iron bar connected to a handle used to turn it. By this means, we could crank up a bucket of water only 20 feet or so from our front door.

From the well house, a sidewalk and then steps led up to our driveway and two-car garage, perhaps another 20 feet away and six feet higher in elevation. The garage was built from debarked logs, creosoted to prevent rot, and with a tin roof and wood-slat sides, painted white. Across the driveway, a line of black pines stood on a narrow two-foot-high ridge separating the driveway from an old dirt road that led a mile or so past the house to Town Fork Creek, which bordered a side of our bottomland. Dad and I fenced the bank so we could pasture cows, pausing our work on one hot, summer day to strip and walk the sandy creek-bottom, then lying in it to wash off the sweat.

The Westmorelands owned the adjoining farm, bordering us all the way from the main road to Town Fork Creek, just upstream from our property. Uncle Paul and Aunt Hope were not relatives, though they were the closest to grandparents I had, and were called Uncle and Aunt in the southern tradition of respect for the importance of their relationship to our family, a relationship too strong for Mom to consider linking them to the dust drifting down toward us.

Along his property next to Town Fork Creek, Uncle Paul had given Frank Loflin permission to dip sand. Frank had a small barge on the creek with a pump mounted on it. An auger churned the creek bottom, and the resulting slurry was pumped onto land and through a sieve that was elevated high enough for a dump truck to back under. The sand was intended for Frank's clients and his concrete business. These dump trucks passing on the dirt road just uphill from our house raised the clouds of dust that Mom battled. In the summertime heat of our unairconditioned home, we opened the windows through which the billowing particles drifted. Mom was obsessed with keeping our home spotless, and the dust was an enemy to be forcefully repulsed. Thus, Dad was drafted into battle, soon escalating to chemical warfare.

Dad was a mechanic at the airport 30 minutes away in Winston-Salem. Anything tossed out at the airport had a fair chance of landing at our house—our kitchen cabinets were built from the floorboards of DC-3s. Included in the airport waste stream were 55-gallon drums of solvents used for cleaning parts and degreasing engines. Dad decided they were perfect for keeping down the dust on the dirt road near our home.

When I was quite young, perhaps six or eight-years-old, I can remember helping Dad load one of the drums onto the back of our tractor. The tractor was an old 1948 Ford-Ferguson, a predecessor to the Ford Redbelly that was popular in the tobacco-growing region. It had a three-point hitch on the back with a crossbar to which we could connected balls for trailer hitches and various

farm implements. On the day I most remember helping, we tilted the drum of liquid onto the crossbar so that it lay sideways, the bung at the low point. Dad climbed onto the old tractor, started it, and lined up the bung over one of the tire tracks in the dirt. I took a pair of large pliers and opened the bung until the liquid began to slowly drain out. Off Dad went, driving the tractor up and down from in front of our house to where the dirt road met our driveway. Each tire track got a good coating of the oily fluid.

Near the garage, a cut through the pine trees allowed access to the road from our driveway, and 50 yards or so towards the main highway, the driveway and dirt road connected. Together, these formed a loop that we could circle on our bicycles or, later, on a go-cart that Dad salvaged from somewhere. As we would loop around, I can remember the oily dirt underneath the tires, looking a bit like a chocolate brownie that had been squished. Meanwhile, the fluid was doing an exemplary job of holding down the dust.

My dad was not alone in pouring waste fluids on the road to keep down dust. For example, the Times Beach, Missouri, Superfund site (see [here]) also began with application of waste oil on dirt roads. Superfund is the common name for a federal law passed in 1980 to identify and clean up the worst of the nations abandoned messes. Other examples include old mines and inactive industrial sites. Among the chemicals at Times Beach were PCBs and dioxin. We have no idea what was in the drums Dad brought home from the airport. But like my Dad, many people did not associate the waste fluid they dumped on the ground surface with the ground water that someone in the future might drink. Most did not realize that the oily dirt itself would become toxic.

Ignorance of chemistry was hardly limited to my Dad. For example, dioxin is naturally occurring in low concentrations but is also created as a byproduct of activities that involve that involve burning organic material when chlorine is present. In the case of Times Beach, the source of the dioxin was the byproduct from a company producing an antibacterial chemical used in soap, toothpaste, and disinfectants used around the house. In the 2004 attempted assassination of Ukrainian President Viktor Yushchenko, dioxin was a key ingredient in a poison used, resulting in chloracne, a disfiguring of his face that was not fatal but required hospitalization and skin grafts. Thus, our increasing understanding of the toxicity of dioxin shifted its destructive application from accidental to intentional.

It was Rachel Carson who first drew significant attention to the truth that not all living is better through chemistry. By that time, my Dad was in middle age, and as I've said, he was hardly the type to keep up with literature about the environment. Despite that, he certainly had no intention of poisoning his family nor himself. And establishing exposure and resulting harm is impossible, However, the fact remains that when I was 19, Dad was diagnosed with leukemia and began chemotherapy. (More [here.]) Looking back, it is a bit ironic that exposure to chemicals may have been the cause of his contracting leukemia and that a different set of chemicals was injected into his veins, aimed at restoring his health by destroying all his white blood cells.

Only later, in graduate school, did I recognize that the waste Dad dumped

on the road might have entered our well. By that time, many years had passed, and only Mom lived at the house. She resisted switching to piped-in water, finally doing so not because of health concerns but because of constant worry that the well was going to go dry, despite its having lasted for decades. During most of those decades, Mom also smoked Marlboros, once again a huge negative health effect of which we were unaware when Mom first smoked. She, too, died of cancer.

There are those who argue that in the face of life's uncertainty, *Ignorance is bliss.* Or they argue that scientists are perpetrating hoaxes upon the American people. Certainly there have been some cases of misbehavior, and there have been some times when it is easier to turn a blind eye than confront the truth and work for change. Still, it's hard to see how Mom would have been worse off knowing the truth about smoking. Eventually after doctors identified the health effects, she made the choice to quit. And the airport is no longer allowed to send home with its employees drums of waste fluids. In both cases, I give thanks for scientists and government regulators.

Recently, I began the task of selling the house, removing decades of accumulated memories—old shoes from the 50s, toys from my childhood, and old black-and-white photos—but leaving scattered about the three-acre lot multiple old barns and outbuildings in various states of disrepair. A log barn, painted green has a few windows with glass from an airplane, one pane of which has a hole where my baseball went astray. Up the hill, the old road passes by, now covered with gravel—no sand trucks and little dust in decades. Instead, a cable blocks passage, locked to keep out four-wheelers and uninvited hunters. Between the road and house, the old well cover still stands, now brick that I laid the summer after Dad died. As I lift its cover one last time, I see small roots penetrating the shaft walls and the reflection of the water below. The mercury-thermometer-shaped well, though no longer used, probes the earth, monitoring the flow through a good vein.

Teaching with *A Good Vein*

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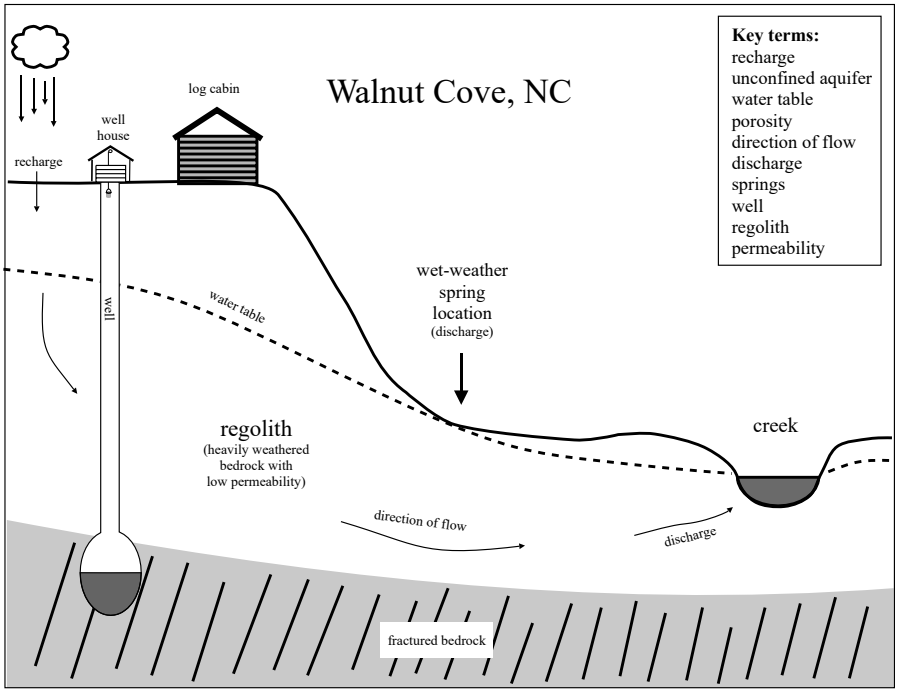
The approach I use at the beginning of the section on groundwater is to introduce my home in Walnut Cove, NC, and to tell an abbreviated version of *A Good Vein* as I sketch either on the board or on a document camera, depending on the technology available in the room. At the time I first tell the story, I assume the students know virtually nothing about groundwater. I will go back later and reinforce concepts with diagrams from the textbook. The purpose of this introduction is instead to capture their interest, show the relevance to their lives, and try to tell a captivating story that provides a framework for memory and better understanding.

I begin by drawing the surface shape and put the house at the top of the hill. As it develops, the cross-sectional figure looks like this:



My home near Walnut Cove, NC.

Then I introduce and draw the following elements while defining needed terms:

1. Recharge—where water enters the ground. I draw clouds and rainfall and show it soaking into the ground.

2. Unconfined aquifer: The water is free to soak downward with no low-permeability *confining layer* to impeded its journey (downward arrow).

An *aquifer* is rock or sediment containing sufficient water to supply springs and wells.

3. Water table—the point below which all the openings in the rock and soil are saturated with water. As the rain infiltrates, it reaches the water table (dashed line), which forms the top of an unconfined aquifer. In a wet climate, the water table mimics the ground topography—high under hills and lower elevations in valleys.

4. Porosity—percentage of the sediment or rock made up of openings into which the water may seep.

5. Direction of flow—water flows downhill. If the elevation of the water table is lower, then that is the direction the water flows (directional arrows).

6. Discharge—where the water leaves the ground for the surface. The banks of the creek are one location (arrow); springs are another.

7. Springs—Where ground water flows onto the ground surface. If the water table intersects the ground surface, water may seep out, forming a spring (mark location). In an unconfined aquifer, the water table changes seasonally. In wet weather, it rises.

8. Well—another point of discharge, this one being manmade. My dad's well penetrated through the low-permeability regolith into the fractured bedrock below. Regolith is a layer above the bedrock of unconsolidated material, often formed from heavy weathering of the bedrock itself.
Thought question: Why isn't the water in the well at the height of the water table? (Insufficient water drains out of the low-permeability regolith before it evaporates in the huge hole dad dug.)

9. Permeability—a measure of the ease with which water passes through the aquifer.

I end the presentation by talking about Dad's application of solvents to the road above the house and well. Occasionally some students have heard of Superfund Sites and even Times Beach. We then do a lab focused on the movement of contaminants through the groundwater. See Lab 11 at

http://www.daleeasley.com/physical-lab.php

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Also, feel free to email me at deasley@dbq.edu with any questions or suggestions.