Why We Know So Little about Underground Water Movement

Water supply damage or contamination possibilities causes more concern about Marcellus Gas Shale drilling than any other single issue. Two points of view contribute to this concern. First, what is out of sight is out of mind. Second and much more significantly, we know very little about underground water movement. What knowledge we do have has developed from catastrophes or near catastrophes. The two motion pictures, *Erin Brockovich* (Julia Roberts) regarding chromate waste, and *A Civil Action* (John Travolta), general chemical waste, correctly presented and appropriately dramatized the challenges of both legal actions. Each film "superficially" touched on the body of knowledge needed to prove water contamination and the harm that contaminated water could bring to people.

Aquifers, underground reservoirs of water cannot be solid rock. Only porous underground layers can contain water. Gravel and unconsolidated sandstone are among the most porous layers available that can serve as significant water reservoirs. Consolidated (bound) sandstone, less porous, can also contain water in reduced quantities. Generally speaking, limestone, coal, shale, sedimentary "rocks," for example can serve as moderately effective barriers to the vertical movement of water.

In Western Pennsylvania, almost any well drilled to a reasonable depth, less than 200 feet, will provide a significant water flow, more than 2.5 gallons per minute (the flow rate normally required for mortgage approval). By contrast, New England wells often must be drilled deep (200 to 800 feet) into granite to attain a flow rate often barely meeting the 2.5 gallon per minute flow rate.

With good fortune prevailing, a drilled well in western Pennsylvania will provide an acceptable flow rate and of such a quality that follow-up treatment, water-softening or iron removal, may not be necessary. Usually this aquifer lies below sandstone or gravel and above limestone. Clay subsoil often overlies the sandstone or gravel, limiting rapid movement of surface water into the aquifer.

A BRIEF HISTORY OF WATER "PROBLEMS"

Strip Mining Impact

Often, owners adjacent to an operating strip mine encounter the earliest effect of loss of their well water. The stripping process has "cut through" the aquifer, opening it to a lower level, allowing the aquifer to drain – just as if the drain plug had been removed from the bath tub.

The delayed impact, well water becoming intensely "red," iron or "black," manganese, arises well after restoration. "Stripping," removal of the overlying soil and rock strata, insures that the overlying rock becomes smaller "rocks" which now have a large surface area. This allows rain water to leach iron or manganese from the exposed surfaces. When the former "bathtub," the strip pit, accumulates enough water to flow into the previous drinking water-providing aquifer, red or black water often results.

Deep Mining Impact

Normally, deep mines have had a small, limited impact on the Slippery Rock area (This contrasts with areas to the east, south, and west of Pittsburgh.) Locally observed effects might lead to acid water, red water, or “sulfur” in the water. The attached copy of an article from the *Pittsburgh Post-Gazette*, (October 9, 2011, pp. A13, 16) presents the impact of deep and long wall mining. The detailed comments about home, property, water supply damage, and lack, or slowness, of remediation especially, parallel observations of Marcellus Shale gas drilling in eastern Pennsylvania.

Oil and Gas Drilling – Once Upon a Time

Until sesmic surveys conclusively outlined the boundaries of the Marcellus Shale as a major natural gas resource, oil and gas wells in Pennsylvania were simple vertical bore holes into both oil- and gas-bearing sand beds. These were once seashore beaches, rich with vegetation which ultimately became petroleum and natural gas. The loose sand particles allowed both oil and gas to readily flow toward the borehole for easy pumping.

Legislation protecting well water supplies dates back to this era of drilling. Owners of water wells near drilling operations were protected from water loss or supply damage if the well was within 2000 feet of the borehole and the damage occurred within six months of drilling start. Technology has changed since the era of “simple” drilling and production technology.

Pennsylvania wells flow slowly, continuously, and reliably. Neither “fracking” nor advanced recovery methods, water or carbon dioxide injection, are generally useful or have been economically beneficial.

CONTAMINATION

Four examples of water well contamination stand out in recent history.

Erin Brockovich details the health problems resulting from water well contamination. The chromate-dichromate family has an important role to play in minimizing chemical corrosion **within closed systems**. Chromate-dichromate leakage from Pacific Gas and Electric electrical generating plant cooling towers led to the discovery of excessive community occurrences of – and deaths from – cancer.

A Civil Action was founded upon the excessive number of leukemia cases observed in the neighborhood of a Massachusetts-based W R Grace Company manufacturing plant that disposed of waste chemicals by injecting waste water into an underground aquifer. Massachusetts citizens of that community obtained their water from a municipal water supply tapping that aquifer.

The community of Harrisville, Pennsylvania, uses the Grove City sewage treatment plant to avoid recycling the obvious. Previously, Harrisville citizens periodically suffered outbreaks of diseases associated with poor sanitation. The comparatively shallow water wells of Harrisville pass through and lie in an area of sandy surface soil. The problem had existed for years; yet, sewage plant “tap-in” did not occur until the 1970s. You probably won’t find this prominently recorded in Harrisville’s community history.

The foaming kitchen taps and back yards of rural, densely-populated, central Long Island and southwestern Connecticut were related through pumping well water. Shortly after World War II, detergent manufacturers switched laundry detergent ingredients. The non-biodegradable detergent was cycled from sewage system leach bed to the drinking water from wells. Non-biodegradable detergents first appeared in the late 1940s. The foaming problem appeared in the mid 1950s.

In the first two cases, decades passed before sufficient evidence of a health epidemic could be detected. Who knows how quickly diseases “passed through” the residents of Harrisville? The Long Island and Connecticut foaming faucets required less than a decade for the problem to appear.

The problem of contaminated water appears either noticeably in the water, as color or taste, and not so noticeably – or too noticeably – often slowly – in people.

LOCATING THE PROBLEM

Once contamination has been noted and identified, the extent of contamination can only be established by sampling. In an aquifer, the contaminated region can be described by concentration and well location. Since not all wells may tap the contaminated aquifer, not all wells within the defined boundary may show evidence of contamination. A contaminated aquifer can be described as a "pond" within a lake with pond depth corresponding to contaminant concentration and a perimeter, "beach," showing no contaminant.

Once the contaminant has been identified, the source must be located. Where the contaminant concentration is highest, the "pond," deepest, this site should be closest to the source. The contaminant identity often points directly to the source. Rarely, records maintained by the source provide limited insight into how rapidly the contaminant has moved through the aquifer. Most likely, no records will be available!

MOVEMENT

The oil and gas industry has measured, porosity, permeability, and transport rates in the strata of vital importance to it. Only sand and gravel beds bearing oil or gas have had these characteristics measured; water does not exhibit the same flow behavior as oil.

We do know that a high concentration will slowly spread to become a lower concentration in an aquifer. Because the substance must wander around sand grains and pebbles in gravel, the path followed is longer than a straight line – requires more time.

If contaminated wells, sampled for a long period of time, at least a year, show concentration changes, some inference regarding the rate of contaminant movement can be made. This information is only valid for geological stratum **which is contaminated**!

THE PROBLEM

Aquifer flow velocities, movement direction, and substance diffusion rates can only be studied by deliberately contaminating an aquifer. The second issue is time – which costs money – a lot of money!

The short list of agents suitable for deliberate contamination are primarily fluorescent dyes that readily degrade in sunlight and oxygen. These are suitable for detecting sewage disposal system leach bed leaks and stream flow dilution. To deliberately introduce these dyes into an aquifer from which people might obtain their drinking water is simply not done! People, given a choice, are not going to tolerate *lime green* drinking water! We have too little knowledge of what takes place underground to risk deliberate damage.

CONCLUSION

What we know about the movement of water, water containing contaminants, or contaminants under the surface of the earth arises from an accident, a deliberate act to minimize disposal cost(s) prior to environmental awareness, a now illegal act, or a tragedy!

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