Water Mining for a Pot of Gold

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"In this arid state, a drop of water is like a drop of gold." San Pete River Water User - 1967

There has long been hopeful speculation, particularly in arid Utah, of the existence of deep, untapped underground rivers, flowing with limitless, ancient water which will solve all of our water resource needs and fulfill someone's get-rich-quick dreams. It is well established that there are isolated caches of 'fossil water', or paleo-groundwater around the world, that originated as precipitation and recharge many millennia ago when the climate and even the local geology were different. Changes in climate and geology can trap water in underground storage basins, sometimes without any further recharge or discharge. Prominent examples of these aquifers are; the Nubian Sandstone aquifer, the world's largest fossil aquifer, underlying the Sahara desert and the Kalahari of northern Africa, with more than 120 billion acre-feet* of water, and the Ogallala aquifer located beneath the Great Plains of North America with 3 billion acre-feet of water in storage.

The deposition of the Ogallala aquifer material dates back 2 to 6 million years, from late Miocene to the early Pliocene age when the southern Rocky Mountains were still tectonically active. Rivers and streams, from the uplands to the west, cut channels in a generally west to east or southeast direction. Erosion of the Rockies provided alluvial and Eolian sediment that filled the ancient channels and eventually covered the entire area of the present-day aquifer, forming the water-bearing Ogallala Formation. This formation has been discovered and exploited and is currently satisfying the agricultural water demands from Texas to Nebraska. Unfortunately it is being over pumped and depleted by as much as 10 million acre feet per year, lowering the underground water level drastically and potentially drying it up completely in the next 25 – 50 years.

There are other examples of prominent aquifers closer to home, such as the carbonate aquifer that spans Utah and Nevada, that is the focus of the latest Las Vegas quest for more water. The Basin/Range composition of the western and northern part of Utah typically has wide alluvial valley aquifers that are recharged by the snowmelt from the mountain streams or through the underlying bedrock. The groundwater of the eastern and southern part of the state is more bedrock controlled with water flowing in the joints and fractures of the compartmentalized bedrock or thru the complex bedrock itself, if it is porous enough.

Ogallala Aquifer – High Plains Underground Water Conservation District No. 1

Because of this hydro-geological diversity within the aquifers, there are major variations in a aquifer's storage capacity, or 'storativity', between unconsolidated granular sediments and the consolidated fractured rock. These huge, porous sponges can store vast amounts of water in their interstitial spaces. The ancient channels embedded in the aquifers can be filled with relatively porous sands and gravels with higher 'transmisivity' that provide a conduit for water movement, interpreted by some as an 'underground river'. Consequently, groundwater can slowly flow if there is a gradient of slope or head to force the movement of water from a recharge area to a discharge or 'abstracting' point such as a pump or spring. This groundwater flow usually takes place very slowly in the interconnected pores, joints or fractures of the bedrock.

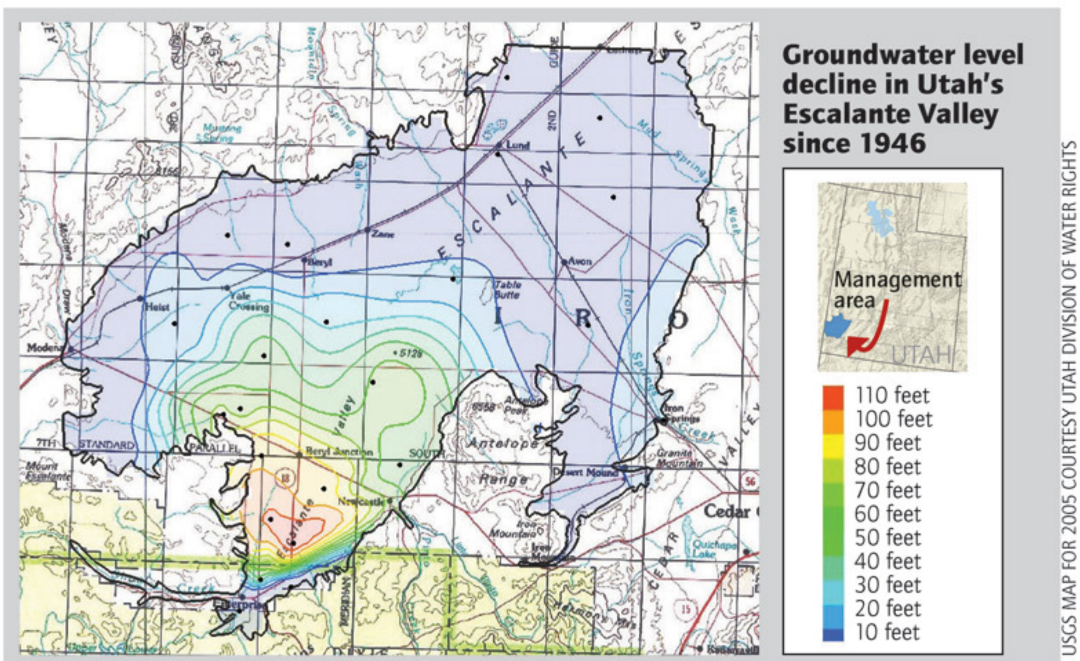
Some of these ancient aquifers are buried deep under confining layers with little relative gradient and no recharge or discharge points. When geologic changes seal an aquifer off from recharging or discharging, the water becomes trapped inside and is known as 'fossil water' and is considered a 'non renewable' resource. Removal of the non renewable ground water is sometimes referred to as 'water mining' because the water is not being replaced naturally at the rate it is being abstracted. Normally, aquifer storage act as underground reservoirs, transforming highly variable spatial and temporal natural recharge, such as desert thunderstorms, into more stable and predictable discharge or abstraction regimes, such as a spring or a well. This results in 'residence times' for the water that are counted in decades or centuries for a typical aquifer while a confined aquifer may seal this ancient water for millennia.

Although these confined aquifers are isolated from the overlying land surface, they are not completely removed from the groundwater system as a whole. Drawdown from pumping or mining of water from the confined section of an aquifer often effect the contiguous, unconfined sections causing leekage downwards or upwards between the layers. Drilling deep wells into 'isolated' freshwater formations may induce leekage from the overlying aquifers into the 'independent' aquifer below. Initially most groundwater aquifers are perfectly balanced and interconnected, natural systems, that we affect and unbalance the minute we disturb them. The terms 'safe yield' or 'sustainability' are misleading and difficult to determine with respect to the groundwater balance because of the instantaneous and delayed cause and effect of any intrusion into the natural balance of the ground water system. All of our actions have consequences and cause infringement or impairment on the balanced system and other users of the system.

Aquifers can provide underground storage reservoirs larger than any dam on earth. The Ogallala aquifer holds over 100 times as much as Glen Canyon Dam and the Nubian aquifer holds more than 4000 times as much as Hoover Dam. Recharge and reuse of these aquifers can provide storage for water systems that do not have the issues of normal dams such as; evaporation losses, the risk of failure, high construction costs or overt environmental impacts. We can utilize and affect these aquifers by taking more water from them in times of drought, or injecting water into it in times of plenty. We can also affect the recharge patterns of aquifers with changes in land use such as irrigation, urbanization, or changes in the natural vegetation. These changes in land use patterns may result in what is termed 'double resource accounting' because we can affect both inflow and outflow.

Overexploitation of the resource is often difficult to determine because of the time lag involved in achieving equilibrium from varying loading conditions. Tolerable rates of abstraction are also difficult to define and they must be determined on an iterative basis to be relevant, especially in arid, changing climates where recharge episodes can be sporadic and intense. There are other social and economic affects to consider, besides just the water balance, such as the effects on other water users, other states or contiguous countries, dependant ecosystems, water quality degradation, salinity concentration, and ground subsidence.

Utah Water Right law and the corresponding legal case precedent allow for a 'reasonable' impairment or infringement on the groundwater resource by different users since it is recognized that this is largely a non-renewable resource, out of equilibrium, that every user shares and affects. Appropriation of non-renewable, groundwater storage is vastly different in this way than Appropriation of the sometimes limited, but often-renewed surface water, where impairment is forbidden. Groundwater management plans must therefore be formulated and agreed on by all the stakeholders, from the water users to the water regulators, from the public to the politicians and from the economists to the ecologist. Honest and comprehensive costs and benefits of groundwater exploitation should be compared, considering our true affect on the system and the cost of other alternatives. Even the Nubian and Ogallala aquifers are not infinite or immune to our influence, nor are our smaller, local groundwater sources. Wise use, acceptable yield and sustainability are an imperative, not an option.



Sources:

The World Bank - GW-MATE, "Sustainable Groundwater Management Concepts and Tools" and "Utilization of Non-Renewable Groundwater" and "Characterization of Groundwater Systems", Foster, Nanni, Kemper, Garduno and Tuinhof, 2002-2006.

The High Plains Underground Water Conservation District No. 1 – The Ogallala Aquifer, www.hpwd.com/the_ogallala.asp.

*An acre-foot is 325,000 gallons, or enough water for a large family or enough water to cover a football field with one foot of water.