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Column Theme: Groundwater—Conflict and Crisis

Water Wars, War of the Well, and Guerilla Well-fare

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Introduction

To get a feel for how sensationalist the term "Water wars" is in the media, consider that a search on Google leads to nearly 31 million results. The water wars "tempest" appears to be part of a mindset ranging from the famous quote apocryphally attributed to humorist Mark Twain "Whiskey is for drinking; water is for fighting over" to comments by United Nations Secretary Generals. Zeitoun and Miramachi (2008) chronicled the proclamations from Boutros Boutros-Ghali known for his 1991 quote "the next war will be fought over water, not politics," Kofi Annan for his 2001 quote "fierce competition for freshwater may well become a source of conflict and wars in the future," and Ban Ki Moon in 2007 for his opinion piece for the *Washington Post*, stating that "Darfur is an environmental crisis—a conflict that grew at least in part from desertification, ecological degradation and a scarcity of resources, foremost among them water." Just the other day I received a call for papers from the *International Journal of Sustainable Society* for a Special Issue on "Water Wars in the 21st Century along International River Basins: Speculation or Reality?"

The likelihood and significance of boundary disputes over the territorial integrity of a state and the extent of government control are greater now than at any time since WWII, especially with respect to transboundary movements where institutional capacity and international law are in the initial stage of formulation (Anderson 1999). Surface and groundwater crossing international boundaries present increasing challenges to regional stability because hydrologic needs can often be overwhelmed by political considerations. There are 270 international river basins and more than 270 transboundary aquifers (Wolf and Giordano 2002; Bakker 2009; Puri and Aureli 2009). The basin areas that contribute to these

rivers comprise approximately 47% of the land surface of the Earth, include 40% of the world's population, and contribute almost 60% of freshwater flow. Within each international basin and overlying each transboundary aquifer, the demands from environmental, domestic, economic users, and the inputs of pollution increase annually, although the amount of freshwater in the world remains roughly the same as it has been throughout history. Given the scope of the problems and limited resources available to address them, avoiding water conflict is vital because conflict is expensive, disruptive, and interferes with the efforts to relieve human suffering, reduce environmental degradation, and achieve economic growth.

Hydroschizophrenia and the Silent Revolution

Environmental flows and ecosystem health are more dependent on groundwater than previously thought. Gautier (2008) estimates that 36% of river runoff comes from groundwater, yet water management has long suffered from a case of "hydroschizophrenia"—the creation of separate surface water and groundwater governance and policies despite the recognition of the hydraulic connection between both hydrologic regimes (Llamas 1975).

Groundwater use is increasing because it is a "common" resource available to anyone with the financial resources to drill, equip, and power a well (Moench 2004). A "Silent Revolution" is occurring where millions of farmers pursue short-term benefits associated with the intensive use of groundwater for agricultural use, especially in India, China, Mexico, and Spain. Proactive governmental action is needed to avert water conflicts between neighboring users, user groups, states, provinces, and nations (Llamas and Martínez-Santos 2005). A comparable situation exists with permit-exempt wells typically reserved for domestic, stock, and garden use in many states within the United States. The number of wells or shallow "water extraction mechanisms" is on the order of millions in many parts of the world as dramatic changes in drilling technology, pumping technology, and the availability of electrical and diesel power have increased over the past 60 years (Table 1).

Pumping of groundwater is among the most intensive human-induced changes in the hydrologic cycle. According to Zekster and Everett (2004) and Shah (2009), groundwater is the world's most extracted raw material, with withdrawal rates approaching 800 to 1000 km^3 per year. The majority of the world's cities rely on groundwater to some degree for their urban water supplies, and Giordano (2009) reports that developed groundwater contributes to the global urbanization underway today. As a consequence, the global economy is becoming increasingly dependent on groundwater.

War of the Well?

Most water professionals are familiar with transboundary disputes over surface water. The media and academic journals are replete with national and international examples. In a global review of local conflict and water, Thomasson (2005) determined that the root causes of water-related conflicts included limited resources, control or distribution, quality of the resource, and large infrastructure projects.

Table 1
Number of Wells in Select Countries

Country	Number of Wells
India	19–26 million "wells" or water extraction mechanisms
United States	14 million
China	3.4–3.5 million
Germany	500,000
South Africa	500,000
Iran	500,000
Pakistan	500,000
Mexico	70,000
Taiwan	37,000
Mongolia	27,000
Ireland	10,000
Malta	10,000
Costa Rica	5,000

Source: Data from Shah (2009), Moench (2004), and National Ground Water Association database.

Transboundary disputes associated with groundwater are less well known, yet are becoming increasingly newsworthy. These disputes involve quantity, quality, and distribution with participation from many scientific disciplines, special interest groups, and the public. Until 2004, conflicts over transboundary groundwater have generally focused on contamination of wells (Gleick 2009). In 2006, the *Washington Post* reported a "War of the Well" between two neighboring clans in Somalia. Closer to home, the state of Mississippi filed a lawsuit against the City of Memphis, Tennessee, in 2009 for capturing groundwater stored in the Memphis Aquifer underlying Mississippi and is seeking 1 billion dollars in damages (Cameron 2009). Likewise, the states of Utah and Nevada settled a dispute in 2009 over water stored in a shared fractured rock aquifer that will serve as part of the municipal water supply for the City of Las Vegas, Nevada, and will be conveyed through a pipeline 350 miles in length and costing nearly 4 billion dollars (Bredehoeft and Durbin 2009). The viability of the project remains in play as a Nevada judge challenged the authority of the Nevada State Engineer on granting a water right for the project and as appeals are filed.

Water Wars: Myth or Reality?

The history of international water treaties regarding surface water is robust. Over 400 treaties have been inventoried with the earliest dating back to 2500 years Before Common Era (BCE) following the last documented war over water in Mesopotamia along the Tigris River (Wolf and Giordano 2002). The history of cooperation over groundwater resources is much less robust,

with only one treaty specifically addressing transboundary groundwater and only a small percentage of the international water treaties with provisions for groundwater (Matsumoto in Delli Priscolli and Wolf 2009). Resource economist David Zetland (2009), in his preeminent blog Aguanomics (http://aguanomics.com/) on "Why We Don't Have Water Wars" states "If the war is over water, then their [winners] enjoyment can be spoiled by the losers, who have many and easy ways of destroying the quality of water.... If this should happen, then both sides lose, changing war from a zero-sum game into a negative sum game.... This is basically an ancient form of mutual assured destruction." In a new book on the topic, Gordon (2008) reports that (1) multilateral accords display levels of interstate cooperation roughly equal to that of bilateral accords; (2) the number of treaties signed and ratified far exceeds instances of actual water redistribution; (3) water scarcity alone does not explain a nation's willingness to negotiate and cooperate; and (4) "negotiation and common pool resource theories appear to yield the highest explanatory value." Yet Zeitoun and Miramachi (2008) indicate that "...all is not quiet on the waterfront." Conflicts of distribution, comanagement, and utilization persist along the Nile, Mekong, Tigris, Jordan, Indus, Ganges, Amu Darya, and several other transboundary rivers and aquifers... and that "not all cooperation over water is pretty and more times than not conflict and cooperation co-exist."

Guerilla Well-Fare

Conflicts over water require a holistic approach to address multidisciplinary and multimedia issues. Adler (2000) indicates that disputes over water are "often large in scale, broad in impacts, and laden with values that are at odds with each other. They are emotional to both 'conscience' and 'beneficiary constituents.' At issue in many cases are matters of culture, economics, justice, health, risk, power, uncertainty, and professional, bureaucratic, and electoral politics." At local scales, conflicts may arise between parties because of the land-water nexus and the large investments required to purchase and develop the land, while trying to weigh the value of maintaining a quality of life through open space initiatives and preserving local water quality. In both developing and developed countries, conflicts also arise due to the plethora of beliefs held by the various parties surrounding the occurrence of water under the land.

Conflicting conceptual models are part of the technical training of hydrogeologists focusing on the intellectual method of "multiple working hypotheses" introduced in the late 1890s by Thomas Chrowder Chamberlin (1897). The structure of the method of multiple working hypotheses revolves around the development of several hypotheses to explain the phenomena under study. The method builds the political credibility of science and makes for better science. Stockholm Water Prize laureate J. A. "Tony" Allan offers that "The findings of water science play a role in the politics of allocation and management. But they will generally be subordinate to politics. After all, water flows uphill to money and power" (Bleckner 2008).

Disputes over groundwater resources are particularly susceptible to the "dueling experts" syndrome. Wade (2004) describes the disputant's behavior in the dueling experts syndrome as having the following characteristics:

- Employs an expert (ours is the best in the field).
- Hires an expert who has a reputation for favoring disputants.
- Preferred outcome (reputational partiality).
- Tells different stories to own expert (garbage in, garbage out).
- Makes expressed or implied hints at the advice he/she wants from the expert.

Dueling experts apparently exhibit the following characteristics:

- Do not consult with each other (delusionary isolation).
- Tell client what they want to hear (you get what you pay for).
- Refrain from providing "best to worst alternatives" (delusionary certainty).
- Long, incoherent reports (mysterious complexity).
- Refuse to share draft reports (no early doubts of compromises).

The database of information on groundwater resources is less than ideal, and the underlying premise of the field of hydrogeology is based on the concept of multiple working hypotheses, thus fueling the dueling expert syndrome. According to Wade (2004), common causes of conflict focus on missing information, inaccurate data, and procedures of data analysis. Although the dueling expert syndrome is good business for conflict beneficiaries, the "ruling theories," or the antithesis of multiple ways of knowing as described by Wade (2004), is leading to a new generation of "hydrostitutes" who are contributing to a loss of political credibility and a distrust in water science, water scientists, and water engineers by the public (Glennon 2006).

Counter-Culture and Combat Strategies

What do the experts "duel" over? Recalling the "Flower Power" movement that symbolized the protest against the Vietnam War during the late 1960s and early 1970s, I compiled the various myths and paradoxes that have been debated in the editorial and technical commentaries in *Ground Water* since the mid 1990s in the issues map depicted in Figure 1. These issues figure prominently in implementing groundwater policy; dispelling the myths and providing rational discourse on these topics must be addressed if scientists and engineers desire to continue to be trusted by society which uses their work.

Water professionals and decision makers should receive specialized resources and skills that go beyond the

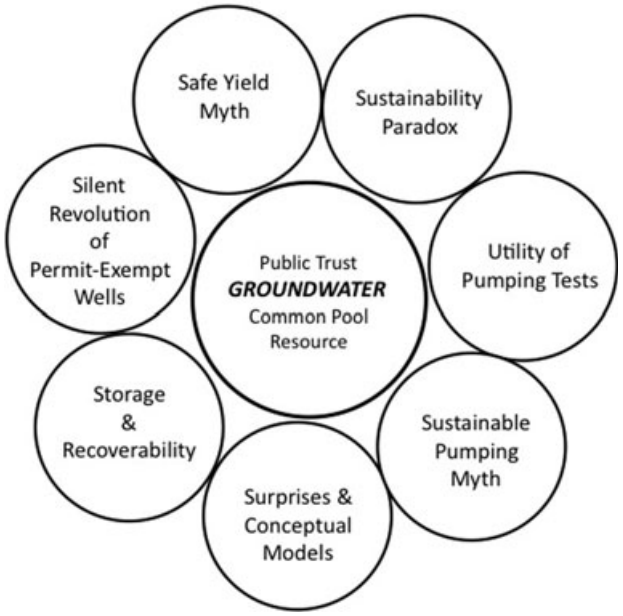

Figure 1. "Flower Power" issues map.

traditional physical systems approach to water resources management. "Substance matters" now has parity with process and relationships when dealing with conflicts over water. According to Adler (2000), "Excellence in conflict resolution for water cases will derive from the way we meet the challenge of achieving powerful 'substantive' solutions to tough problems. Good process and improved relationships—the traditional measures of good mediation in other arenas, are necessary, but insufficient, for greater use of this method in water cases. . . we must do better. We must be able to show outcomes that are Pareto-optimal, better than what can be achieved in litigation, better than expectations, or better than some other party-established baseline."

Conclusions

Conflicts over water can be best described as a "wicked" planning problem that has uncertain boundaries, defies absolute solutions, and can be a symptom of larger problems (Rittel and Webber 1973). Yet, Delli Priscoli and Wolf (2009) state that water compels us to think regionally, that (1) the price for control over an agreement over water is sharing ownership and cooperating in both the process and outcome of the agreement; (2) the transaction costs are escalating beyond traditional management methods; (3) the available money to identify needs is contracting; (4) the public awareness of water resources is growing and changing; and (5) the traditional legal systems are unable to cope with change. These are just a few reasons why water conflicts may be well suited to conflict resolution through collaboration. As Wolf (2008) eloquently puts it, "Water ignores all separations and boundaries save for those of the watershed itself. As such, it offers a vehicle to bring those who share it together. Since it touches all we do and experience, water creates a language through which we may discuss our common future."

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