Changes & Challenges: Reflections on Water Issues & Management in New Mexico

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Bruce Thomson will be retiring from the University of New Mexico where he is a Regent's Professor in the Department of Civil Engineering at the University of New Mexico and is Director of the UNM Water Resources Program. He has a BS degree in civil engineering from the University of California at Davis, and MS and PhD degrees in environmental science and engineering from Rice University, Houston, TX. Bruce teaches in the areas of water chemistry and treatment, groundwater hydrology and remediation, and water resources management. Recent research has included projects on water resources of New Mexico, the impact of energy and mineral development on water resources, and water reuse and treatment. He has served on many federal, state and local committees involved with management and protection of water resources. Bruce was recently elected to the Board of Directors of the Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA). He is a licensed Professional Engineer in the State of New Mexico and received the 2013 New Mexico Public Sector Engineer of the Year award.

A Short Preamble

Being invited to present a retrospective paper on water issues in New Mexico is both an honor and a challenge, but also an indirect public acknowledgment that one is approaching geezerhood. But with approaching geezerhood comes some freedom from traditional constraints in that you don't have to be quite as diplomatic with your opinions because if you offend somebody what are they going to do, fire you? Of course, there's also the risk that you will descend into past memories and pointless reminiscence resulting in total disregard of your thoughts and opinions. I will attempt to find a middle ground; not offend anybody but also not dwell on the past. Nevertheless, it is a pleasure to be offered the chance to reflect on some of the challenges associated with water in New Mexico.

Introduction

During the course of my career there have been remarkable changes in the technologies we have used in water research and management. Calculations were done with slide rules and adding machines. (Aside: Hewlett-Packard introduced a basic scientific calculator the year I graduated from college. Its 1971 cost of $395 would be over $2,200 today.) Water quality measurements were performed by hand using burets, color indicators, and instruments with dials. Computers filled entire rooms, used as much power as a residential neighborhood, and were programmed with punch cards. Cars didn't have seat belts. And students and faculty were allowed to smoke in class. Those weren't necessarily the good old days, but they were different.

One of the most apparent differences between then and now is the lexicon (Table 1). Our terminology has become more convoluted, more oblique, and now avoids words with common negative perceptions (i.e., sludge, garbage, and dump). The words and phrases are also longer (an average of 6.6 syllables vs. 3.8 syllables) as if we can improve our public image of the profession by using more complicated words and phrases.

The evolution of the environmental engineering profession has been driven by the proliferation of environmental legislation. This is stunningly illustrated by a plot I did several years ago of the number of laws that are relevant to the profession (Figure 1). The first Earth Day, considered by many to be the beginning of the environmental movement, was in 1970. In the next 20 years over 30 major pieces of federal legislation were passed, actions that dramatically altered the profession. One of the more provocative commentaries on this change was a talk presented around 1990 by Bob Hogrefe, a water engineer with the City of Albuquerque titled "Whatever Happened to BOD?" that reflected how much the profession had changed as a result of these laws and their subsequent regulations.

Table 1. Changes in terminology in the environmental engineering profession

Old Terminology	No. Syllables	Current Terminology	No. Syllables
Sanitary engineering	8	Environmental engineering	9
Sewage	2	Wastewater	3
Sewage treatment plant (STP for short)	5	Water reclamation plant	7
Water treatment plant	5	Water purification plant	8
Sludge	1	Residuals Biosolids	4 4
Garbage	2	Solid waste	3
Dump	1	Solid waste management unit	8
Septic tank & leach field	6	On-site wastewater treatment and disposal system	13
Drinking water standards	6	Maximum contaminant levels	9

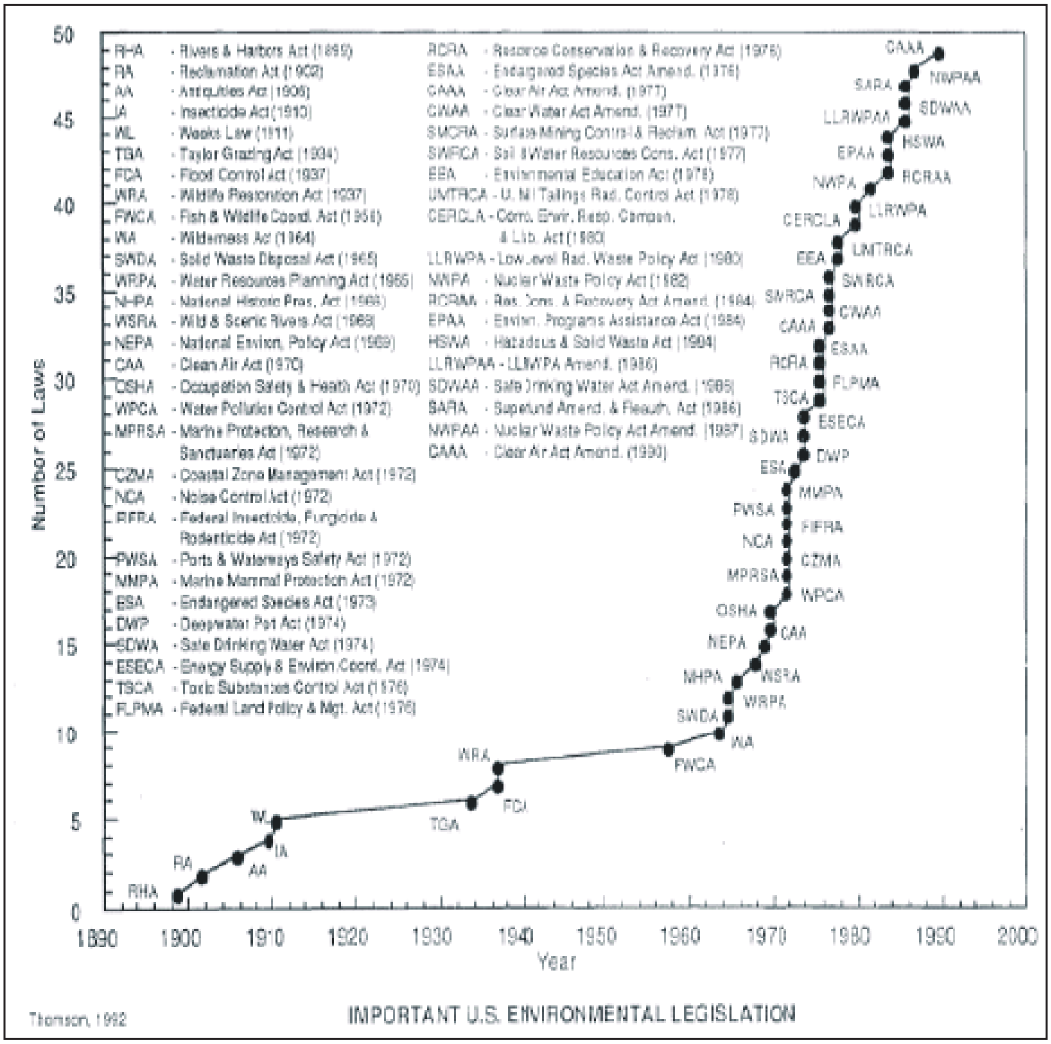

Figure 1. The evolution of major federal environmental legislation with time up through 1990.

Environmental Engineering Technology

As with nearly all technologies, in the last 30 years the advances in the performance of environmental systems have been breath taking, to the point that the effluent from most well operated sewage treatment plants, oops, wastewater reclamation plants meets drinking water criteria. But don't ask me to drink it!

However, sometimes the inflexibility of environmental regulations lead to solutions for problems that don't exist. For example, the Clean Water Act (CWA) requires that all communities use the activated sludge process for wastewater treatment, a proven and reliable but complicated and expensive technology. But many communities in the arid southwest discharge to dry streams and arroyos. Though these are technically "waters of the U.S." as defined by CWA regulations, in reality there is seldom any water in them and certainly no aquatic environment needing protection. So why can't we utilize much simpler and far less expensive technologies such as wastewater treatment lagoons? Pushing the envelope even further are recent requirements for advanced treatment, including removal of nitrogen and phosphorous, from discharges to intermittent effluent dominated streams. We're requiring some of our poorest communities to incur very large treatment costs to protect an aquatic environment that wouldn't exist if the discharge was discontinued.

Another consequence of this myopic regulatory environment is the tendency to require action on new contaminants with little regard to their actual threat to human health and the environment, and with virtually no consideration given to the secondary consequence of the regulatory implications. The classic example of this is the new drinking water standard (maximum contaminant level or MCL) for arsenic.

The 1996 amendments to the Safe Drinking Water Act required that EPA promulgate a new standard for arsenic. This was finally accomplished 10 years later when the MCL was lowered from 50μg/L to 10 μg/L, even though no study of populations in the U.S. or Europe found a correlation between illness and elevated arsenic concentrations. Instead, justification for the standard was principally based on extrapolating down from epidemiologic evidence from rural communities in Taiwan exposed at very high concentrations. The data and several different statistical models are shown in Figure 2. Though it's possible to calculate a reduced risk from this model, the inherent uncertainty is stunning. Nevertheless, based largely on this data and accompanying analysis, EPA passed the new standard that was projected to costs estimated at $5 to $15 M per life saved (Gurian, 2001). Water utilities have stepped up to the plate and most are in compliance with this new regulation, but credible epidemiologists note that we will never be able to actually measure the consequences of this action in terms of reduced mortality or morbidity. At the same time, one can't help but wonder if those very large amounts of money couldn't have had greater benefit by applying them elsewhere.

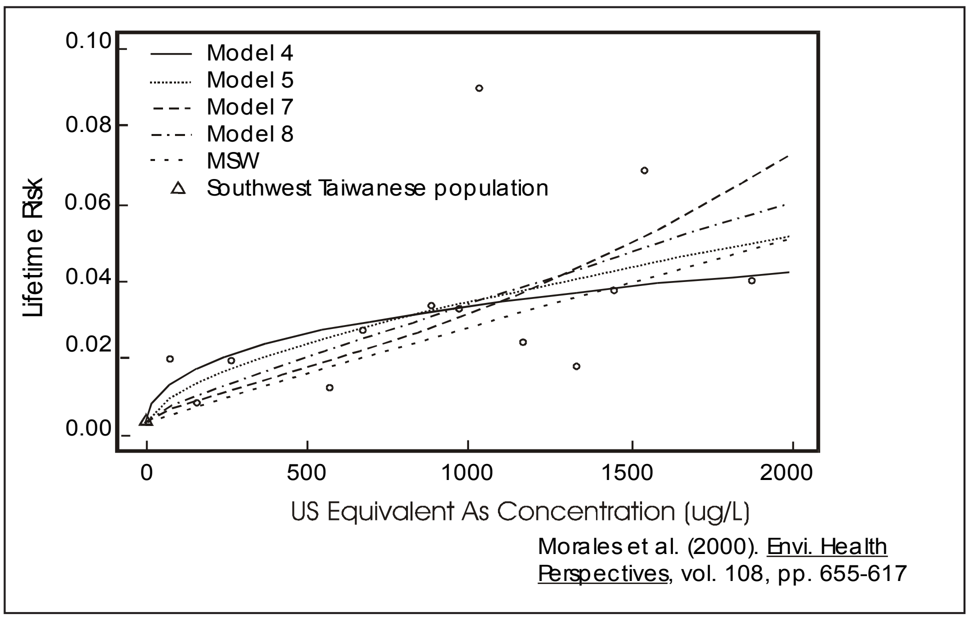

Figure 2. Correlation between arsenic in drinking water and risk (Morales et al. 2000).

Arsenic is an example of a class of compounds that can be referred to as "political pollutants," a description coined by Lamar Miller, an environmental engineering professor at Florida State. Political pollutants are those which the public believes to be a far greater threat to human health than is supported by actual data. I maintain that if Joseph Kesselring had instead titled his 1939 play "Dysprosium and Old Lace" the drinking water MCL for arsenic would not be 10 μg/L today. This is an important lesson that we should remember as analytical chemists develop new methods for detecting ever lower concentrations of aqueous constituents. Although we can measure a constituent in water, proving that it poses a risk to the public is a very difficult, costly, and contentious task.

Water Resources Management in New Mexico

Most of the water resource challenges we face in New Mexico are the result of laws, decisions, and policies that were instituted 100 years ago. It is especially important to remember that NM water law, first codified in 1907 as the Territorial Water Code, was passed and implemented largely as a mechanism of encouraging economic development in the territory. At the turn of the last century, the state's population was less than 200,000 people and its economy was dominated by agriculture, timber, and mining; there was little municipal demand for water and virtually no manufacturing or industrial use. Hence, the water code was intended to support this type of development and protect it into the future (Buynak, 2008).

A plot of the historic volume of Elephant Butte Reservoir (Figure 3) illustrates the history of water supply of the Rio Grande as it provides a way of integrating supplies over the entire basin and also has the effect of providing a running average of data over several years. Through the end of the 20th century, water managers in the state were able to meet nearly all demands for water. This was assisted in part by two decades of unusually high precipitation and in part by groundwater mining of large aquifers in the middle Rio Grande and the eastern plains. Extended drought conditions since 2000 have resulted in recognition of the vulnerability of our water supply to drought and climate change. And falling water tables have increased awareness of the limitations of groundwater as a sustainable source of supply without careful management.

As the state searches for strategies to deal with future water demands, it is worth examining some of the most important institutional laws and policies that constrain rational water management. The original goal of territorial water managers in the territory was to promote economic development. During the first 70 or 80 years of the 20th century, the state developed compacts, laws, regulations, and policies largely to encourage and protect this type of development. In the context of the 21st century social and economic structure of New Mexico, many of these don't make sense. Some examples:

- Why is the right to appropriate water (i.e., a water right) granted forever? Other public resources such as grazing rights are for a limited term. A perpetual water right is a tremendous benefit to the person who holds it but effectively removes it from its owners, the public. Furthermore, ownership in perpetuity introduces all sorts of complexity into managing the resource.

- Does priority administration of water rights make sense? If the principle were rigorously applied, it removes all incentives for conservation by owners of senior rights, often referred to as "use it or lose it." In the absence of adjudication, there is a large uncertainty (chaos might be a better term) associated with managing water because information on the amount and priority date has not be determined (Benson (2012). Furthermore, in hopes of creating order out of chaos, the state and water rights holders are spending a fortune on 14 current adjudication proceedings that take many decades to complete. The state hasn't even begun to think about the 500 pound gorilla in the room; adjudicating the Middle Rio Grande basin.

- The Rio Grande Compact requires storage of water in Elephant Butte Reservoir, one of the hottest and driest locations in the state with a pan evaporation rate of nearly 10 ft/yr. Evaporative losses depend on the lake's surface area, and though the lake averaged about 20% of its capacity from 2008 to 2012 (see Figure 3), during this same time it lost 84,000 AF/yr to evaporation (MRGWA, 2014). This is roughly double the consumptive use by the City of Albuquerque. Agreeing to store water in Elephant Butte wasn't a concern in the 1930s when the Compact was being negotiated because the first three decades of the 20^{th} century were unusually wet and the reservoir had plenty of water. However it certainly doesn't make sense based on 21st century hydrology, hydraulics, and water use. Is it possible to modify the Compact to allow storage in upstream reservoirs that have half the evaporation rate of Elephant Butte and recover some of that water lost to the atmosphere?

- The NM constitution states that water "...is hereby declared to belong to the public and to be subject to appropriation for beneficial use…" In other words, a water right does not constitute ownership, only the right to use it. In keeping with the public lands analogy presented above which notes that the state charges for grazing rights, why isn't there a similar charge for use of the public's water? A modest charge for water use would both provide an incentive to conserve the resource and generate revenue that could be dedicated to water projects.

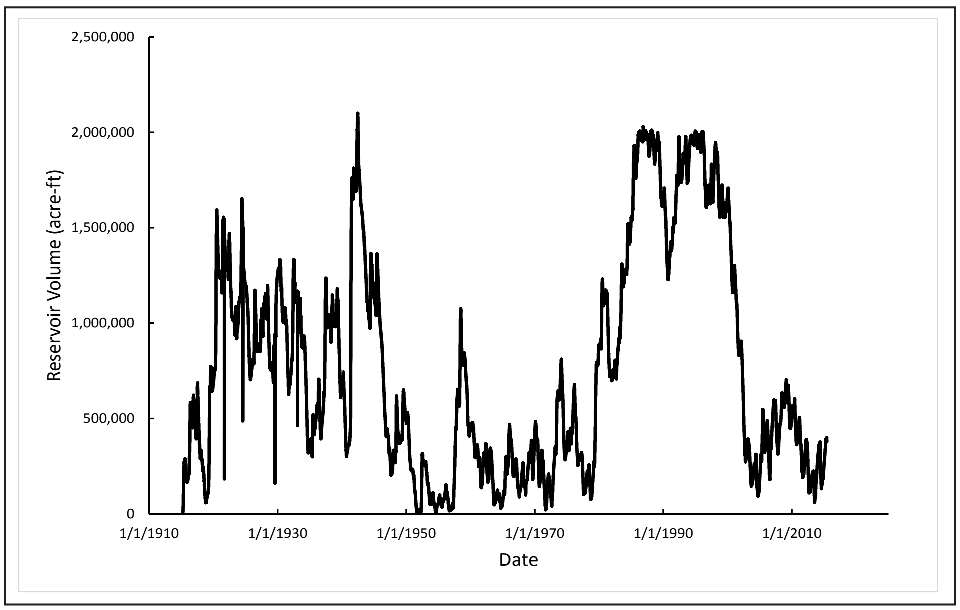

Figure 3. Historic volume of Elephant Butte reservoir

I fully recognize that political realities make each of these constraints impossible to change. The social, cultural, and economic investments that have occurred over the last century as a result of these laws and policies are too solidly integrated into the institutional organization of the state to expect changes. The combination of institutional complexity introduced by the four points noted above, increasing demand for water to meet the needs associated with population and economic growth, and the enormous uncertainties and highly variable nature of the southwestern climate create a classic example of a "wicked problem." This is defined as a problem that is impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize (Rittel and Webber, 1973). Using the terminology of mathematics, our water problems are over constrained.

Though there is no single solution to water problems in NM, there is value in explicitly identifying and considering the root causes. Most meetings and conferences focus on the hydrologic cycle and its uncertainties, especially those regarding possible climate change. Since 2008 it is not possible to attend a meeting of hydrologists and engineers without a discussion of stationarity (Milly et al., 2008). And while variation in the water supply creates challenges, it is the institutional constraints that create the biggest obstacles to innovative management strategies, and these are seldom discussed. As water professionals we should recognize that water management is a wicked problem, identify the issues that make it such, and include them in future dialog on how to address the problem.

Concluding Remarks

Humans have been storing, diverting, treating, and distributing water for thousands of years; consequently the hydrology and water engineering professions are pretty mature. Though we can't control it, we have a high degree of understanding of occurrence and movement of water (i.e., hydrology). Likewise, we can design and construct very effective systems for storing, treating, and distributing water (i.e., engineering). Arguably the biggest challenges facing water professionals are in developing institutional mechanisms for rationally managing the resource. The present institutional system creates near gridlock in which decisions are often made by individuals with limited understanding of the engineering and natural science complexities associated with the hydrologic cycle.

Circling back to the introductory remarks reflecting on my career, I note that one of the first papers I ever published discussed the role of the engineer in the public participation process (Thomson, et al., 1983). This paper made the observation that engineers and scientists seldom take an active role in developing public policy, and yet many of the most challenging issues facing the community have fundamental technical underpinnings. The paper concluded by urging engineers and scientists to play a more active role in the decision-making process, and especially to seek opportunities to lead the public dialog on policies based on technical issues. The water problems we face today have far more technical complexity than were present 100 years ago when the first sanitation laws and water rights laws were being passed. I think it is more important than ever that the plea in that 1983 paper for participation by engineers and scientists in development of environmental and water policies be extended.

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