CHAPTER 14

Public and stakeholder education to improve groundwater management

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ABSTRACT: With water at a premium in California and other Southwestern USA states, there is increasing interest in better coordinating the use of surface water and groundwater to stretch the total water supply. Coordination requires cooperation among local groundwater users, state and federal agencies, and other stakeholder groups that often hold contradictory views. These groups need to develop trust to work together. Education programs that clearly explain the groundwater resource and explore these varied viewpoints can help bring people together and result in better use and protection of the vital groundwater supply.

1 INTRODUCTION

Educating key policy-makers and members of the public and bringing stakeholders together are the main elements of the Water Education Foundation's program to improve groundwater management in California and the Southwestern USA. Groundwater is a key source of water supply in this semi-arid to arid region. As the region's population pressures increase and more surface water is dedicated to environmental restoration, water stored underground in aquifers becomes even more important for city dwellers and farmers alike. As the world's fifth largest economy and a leader in agricultural production, California's efforts to stretch its groundwater resources through conjunctive use may offer lessons for other states, regions and countries. In the face of all these changes, the Foundation, in recent years, has made a strong effort to raise the level of understanding about the groundwater resource.

Perhaps the most important part of the Foundation's program is to publish factual information on groundwater issues, to explain what groundwater is, and the importance of managing it wisely. In California, groundwater is not the focus of a statewide management scheme. Through a number of the Foundation's groundwater education programs aimed at specific audiences, a consensus has emerged that groundwater should remain a locally controlled resource, but because it is a resource important to all Californians, that it can be managed to provide for broad benefits.

1.1 *Who is the Water Education Foundation?*

Established in 1977, the Water Education Foundation marks its 25th anniversary in 2002 as the leading disseminator of impartial, timely, balanced and easy-to-understand educational materials about water issues in California and the Western USA.

Such materials are especially critical today as the region faces the twin pressures of continued economic growth and the desire to preserve and protect the environment. Water quality issues also are of increasing importance.

The Foundation focuses its education efforts on three main audiences: policy-makers in the government, and leading stakeholders in the agricultural, environmental and urban water communities; members of the media, who assist our efforts to educate the general public; and school children –and their families– in grades K-14 (kindergarten through college sophomores).

The Foundation's primary objective in all of these efforts is not to advance one particular viewpoint or solution, but to explain the complexities of various opinions and ideas so that people can make better-informed decisions. A 25-member voluntary Board of Directors, who represent a broad cross-section of the environmental, business, agricultural and public interest communities and a variety of public agencies, private foundations and stakeholder groups, sets general policy goals for the Foundation. A staff of ten develops and maintains an extensive menu of educational products: water tours, conferences and briefings, television documentaries and educational videos, school curricula, and a wide range of publications, including the well-known *Western Water* magazine.

A nonprofit, tax-exempt, impartial organization funded by grants, contributions, sale of materials and attendance at events, the Foundation's mission is to create a better understanding of water issues and help resolve water resource problems through educational programs. Through the years, the Foundation has become a respected source of information on groundwater issues.

2 GROUNDWATER IN CALIFORNIA

Gold extracted from California's mountains and streams in the latter half of the 1800s generated an economic wealth and a rich history that set the pace for growth and development in the next century. A magnet for entrepreneurs, California quickly matured into a world leader in entertainment and tourism, high technology and financial management, manufacturing and agriculture.

Supporting all of these ventures is another precious resource –groundwater– that is extracted from some of the most productive aquifers in the USA. A hidden resource, groundwater is an asset that few people understand yet is increasingly relied upon by growing cities and thirsty farms. A renewable resource, groundwater in some locations is intensely managed and in other places is hardly managed at all.

The role of groundwater in the state's economy is easily overlooked. California's famous system of dams and canals is an understandable source of pride. The groundbreaking public works, including the *State Water Project* and its California Aqueduct, that capture, store and transport surface water runoff inspire water managers from around the world.

The state's enormous groundwater aquifers are estimated to hold nearly 20 times the amount of water that can be stored behind all of California's dams –in total, some 1,050 km^3 of water. If California were flat, the volume of its groundwater would be enough to flood the entire state 243.8 cm deep.

It might seem improbable then to say that California needs to conserve water. The problem, according to the State Department of Water Resources, is that only between 308 km^3 and 506 km^3 of the state's groundwater can be economically reached or is of a high enough quality that it can be used without treatment. In addition, local aquifers are not always large enough to meet local demands.

In addition, California's mediterranean climate characterized by warm, dry summers means there is no rainfall for several months each year. Precipitation also varies considerably by region. It is heaviest on the north coast and can reach more than 254 cm/yr, but decreases as one travels southward. California's inland deserts bordering Mexico can receive less than 50 mm/yr of rain.

The state's surface water systems were built, essentially, to even-out this flow; not only to prevent deadly flooding from years of extremely high runoff and to store water for use in times of drought, but to even out the supply and demand on a yearly basis.

About half of the state is underlain by a groundwater basin (450 of them in all). Most of them are small and some of them are mammoth; many are within 30 m of the surface while others lie hundreds of meters below ground.

On average, about 18,500 Mm^3/yr of groundwater are pumped statewide and the available supply has proven to be a reliable and resilient resource. The aquifers are particularly valuable because unlike the state's surface water, which occurs predominantly in the northern and eastern mountains, groundwater is widely distributed throughout the state, underlying the land where it is needed. Groundwater also is available year-round unlike surface water runoff that flows heaviest each spring.

While many communities rely on a combination of surface water and groundwater, some regions are overwhelmingly dependent on natural underground reservoirs that the public does not see. More than 9 million Californians –nearly one in three– rely solely on groundwater to meet their needs, including the major cities of Fresno and Bakersfield. Statewide, water pumped from wells in a typical year quenches 16% of California's water needs. In a drought year, usage climbs to 25%. Some regions are even more dependent on groundwater. Along California's central coast, for example, 90% of the drinking water is supplied by groundwater.

For decades, California communities have wrestled with the consequences of pumping too much (overdrafting) groundwater, including intrusion of seawater into coastal aquifers and land subsidence. Contamination of groundwater from a variety of pollutants is an increasing concern because of potential health threats and because pollution compromises the ability of aquifers to help meet growing water demands. Some groundwater is polluted with natural elements leached from the earth, including boron and arsenic. Increasingly, health officials are concerned about viruses and bacteria in groundwater. But far greater problems are created by synthetic elements –including some pesticides, herbicides, fertilizers, cleaning solvents and fuel ingredients– that can contaminate the soil and the aquifer.

Prior to modern development, California's visible water system of streams, lakes, marshes and estuaries was more closely linked to the groundwater system of aquifers and springs. Today, a number of contemporary water management strategies are designed to take better advantage of the natural relationship between surface water and groundwater. These more intensive groundwater management efforts have prompted policy-makers to re-examine how groundwater is regulated, how the rights to use groundwater are defined and enforced, and how groundwater quality is protected. Crafting politically and economically acceptable management plans requires more detailed scientific assessments about the functions of particular aquifers.

The push to protect groundwater from contamination, clean-up existing contamination and increase water yields in semi-arid California makes it all the more important for people to understand the role of groundwater in their lives and the best ways to manage and protect the resource.

2.1 *History of use*

California's first European settlers relied on water from streams and springs to meet their needs, including irrigation. The drought of 1880, however, prompted farms and communities to tap the groundwater for the first time in a significant way. Resorting to technologies that had existed for thousands of years, settlers dug shallow wells to expose shallow water tables. At first, the pressure in these full aquifers –the *head* that moved groundwater into low-lying marshes and streams– was enough to push water up to the surface, creating what are known as flowing artesian wells.

As more groundwater was used and water tables fell, windmills and piston pumps were used to lift the water to the surface. In the 1920s, the invention of the deep-well turbine pump and the electrification of rural California put water 30 meters-plus below the surface within reach for the first time. This allowed people to pump larger volumes of water. In the 1940s and 1950s, pumping increased sharply as agricultural operations expanded, particularly in the Central Valley.

The pumping led to overdraft conditions and as the water table dropped farther still and groundwater became more difficult to recover, thousands of farmers in the San Joaquin Valley –some of them having nurtured orchards and vineyards with well water– stood to lose their investments. Delivering water to these growers was the reason for federal investment in the *Central Valley Project*, which was designed to capture Sierra runoff from Mount Shasta in the Northern Sacramento Valley and distribute it to farmers as far away as the San Joaquin Valley south of the city of Sacramento.

In Southern California, groundwater pumping helped to fuel the birth of the modern metropolis. Here, too, over-pumping was a problem, causing, in coastal areas, seawater to be pulled into fresh water wells. In the 1940s when it became clear that demand was exceeding supply in many Southern California groundwater basins, officials turned to court adjudications to determine water rights and yields.

In the San Joaquin Valley, groundwater levels began to rise as the *Central Valley Project* water of the 1950s was joined, in the 1960s, by irrigation water delivered through the *State Water Project*. The great resiliency of the Central Valley aquifers was demonstrated in the late 1970s and again in the 1980s when the recharged underground basins helped offset drought-induced surface water delivery cutbacks.

While natural precipitation and runoff led to some groundwater recharge, by the 1970s, some of the state's regions already had decades of experience with artificially recharging groundwater. Reservoirs and seepage basins were constructed to collect and slow the runoff and encourage percolation.

As of 1950, California pumped 50% of all of the groundwater used in the USA –a statistic that reflects the rapid development of agriculture in a region requiring irrigation, as well as minimal restrictions on how much water property owners could pump. While surface water development has curbed the demand on aquifers, California still accounts for 20% to 25% of the USA's groundwater usage. California and Texas –the second largest groundwater-consuming state in the USA– are the only two states without comprehensive, statewide groundwater regulation or permitting of pumping.

2.2 *Groundwater rights*

California, like most of the arid states in the Western USA, has a complex system of surface water rights that accounts for nearly all of the water in rivers and streams. Riparian rights are held by those with property bordering streams, while appropriative rights are held by those who have a claim to divert and use water away from the source. The legal system was crafted to create certainty in a region of frequent scarcity –essentially setting rules for who gets how much of the limited supply. The California State Water Resources Control Board administers the permit system governing appropriative water right holders.

In more recent years, most states in the Western USA have established surface-like rights for groundwater –defining and dividing a given supply for use as the water right holder sees fit. But in California, the only truly universal law governing pumping is the state constitutional mandate that water not be wasted or put to an unreasonable use. This 1928 amendment requires all uses of water to be "reasonable and beneficial", and establish a standard allowing more equitable resolution of water use conflicts. *Beneficial* uses include irrigation, domestic, municipal and industrial, hydroelectric power, recreational use, protection and enhancement of fish, wildlife habitat, and aesthetic enjoyment. *Reasonable* use, however, is a slippery term. The State Supreme Court has ruled that reasonableness depends "not only on the circumstance but varies as the current situation changes".

Defining groundwater rights in the West has never been easy. From a physical standpoint, groundwater is more difficult to observe and quantify than surface water, which discourages government regulations where it is not essential to solving immediate and serious problems. From a political standpoint, the freedom to pump without restriction –rooted in tradition– has been difficult to alter.

The legal system has been built on this rocky terrain. The courts, in the absence of comprehensive legislation or a statewide system, have established general parameters of rights in the process of settling disputes. Those rights for the most part only come into play when severe shortages occur and aggrieved pumpers sue in search of court-decided rights to extract groundwater.

Early in the 20th century, California courts divided groundwater into two broad categories –subsurface flow and percolating groundwater. Subsurface flow is defined as water moving through the sands and gravels under or next to a stream channel. Subsurface flow is considered to be part of the stream and subject to the same riparian and appropriative rights that guide the use of the stream itself. As a result, the pumping of subsurface flows, while constituting only a small portion of the groundwater in California, is regulated by the California State Water Resources Control Board.

The courts defined percolating water as water moving through the soil drawn by gravity along the path of least resistance. In California, the term covers the vast majority of groundwater. And with few exceptions, the California State Water Resources Control Board does not govern the use of percolating water.

As groundwater disputes reached the courts, judges, in the absence of state statutes, turned first to English common law, which dictated that in owning the surface of the earth a landowner also holds title to everything beneath it, including the water. In semi-arid California, where a common groundwater basin can lie beneath the city pumps or plows of thousands of landowners, the courts needed something more specific to resolve inevitable disputes. In 1903, in the case of *Katz vs. Walkinshaw*, the California

Supreme Court acknowledged that groundwater is not fixed to individual parcels and that the resource is finite. The court ruled that where there is not enough groundwater to meet the needs of all landowners overlying an aquifer, each property had a "correlative" or co-equal right to a "just and fair proportion" of the resource.

That standard is different than the one governing surface water rights, which limits the amount of water that can be used and establishes a priority system for allocating water during shortages. Correlative rights, while acknowledging that shortages may occur, only require that all property owners share equally in the resource until it is exhausted –irrespective of the consequences.

In a number of economic and environmental issues, some say, resources shared in common with few restrictions are ultimately overused, as all participants are encouraged to maximize their use and no participant has an incentive to consider the long-term consequence of overuse. When the consequences of over-pumping are severe for at least five years, groundwater users can ask the court to *adjudicate*, define the rights that various entities have to groundwater in the basin.

In an adjudication, the court can limit pumping to the *safe yield* of the basin, which is the amount of water that can be pumped without causing undesirable results to the aquifer. Through adjudications, the courts can assign specific water rights to water users and can compel the cooperation of pumpers who might otherwise refuse to limit their pumping. Watermasters often are assigned to ensure that pumping conforms to the limits defined by the adjudication. Litigation, however, is time-consuming and costly, in part because it is difficult to determine all of the pumpers and their historic pumping amounts.

Through this process, the courts have adjudicated 16 basins in California. All but two are located in Southern California, where urban development pressures quickly overwhelmed limited aquifers. In adjudicating these basins, early court decisions affirmed the concept of correlative rights and established two other kinds of groundwater entitlements. The courts ruled that among appropriators, the first to pump has the first entitlement to export water. When it is necessary to limit pumping by appropriative users, those limits should be based on how much the users pumped historically. Creating limits based on past use, however, provides an incentive to pump more water than is needed because an appropriator who pumps a lot of water in flush times is entitled to more water in times of shortages.

In 1949, the court went even further, deciding that historical use was the best guide for allocating limited supplies among all pumpers, including those with correlative rights. In the case of *Pasadena vs. Alhambra,* the court said that during times of overdraft pumpers can "prescribe" or seize the rights of another water user by showing that they have been adversely using the other's water "notoriously and openly".

The court said in a case of overdraft, all correlative water users were acting prescriptively against each other. Under the mutual prescription doctrine, both correlative and appropriative users can be required to reduce their water use proportionately. The doctrine, however, also expanded the incentive to all groundwater users to increase their pumping just to establish a record of use that would grant them a bigger share of scare supplies when pumping is restricted.

The California Supreme Court in the 1975 case of *City of Los Angeles vs. City of San Fernando* recognized the perverse incentive and diminished the ability to use elevated pumping records when establishing prescriptive rights. Subsequently, the courts further limited the use of mutual prescription. They prohibited groundwater users from prescribing the rights of municipal water suppliers with appropriative rights. They also provided ways by which correlative water right holders could defend their rights from those seeking to infringe on those rights through prescription.

For the most part, the California Legislature has imposed groundwater regulations only upon the willing –granting specific authority to limit or tax pumping only in basins where pumpers have sought that authority.

Periodically, California has considered, but not implemented, a more comprehensive groundwater scheme. And in contrast with the centralized state-controlled surface water rights, the guiding principle for groundwater management has been that geography is complex, so decision-making is best left to local officials. That principle, however, is coming under increasing scrutiny as California progresses further away from an era when water supplies were expanded to meet all needs and into an era in which existing supplies are carefully managed or reallocated to meet growing needs. Most state officials favor local control.

3 CONJUNCTIVE USE

Conjunctive use is the coordinated management of surface water supplies and groundwater supplies. A more active form of conjunctive use utilizes artificial recharge, where surface water is intentionally percolated or injected into aquifers for later use. A more passive method is to simply rely on surface water in wet years and use groundwater in dry years.

Informally, conjunctive use has occurred since the first drought prompted communities to dig wells. Water managers in Southern California were among the first in the USA to intentionally recharge aquifers. But as water managers seek to make the best use of existing water facilities and wet-year flows, conjunctive use has taken on more formal meaning.

The state in the 1980s purchased 80.9 km^2 along the Kern River west of Bakersfield to develop an underground water bank –soaking water into the sandy soils in wet years and pumping it out in dry years. A variety of regulatory hurdles frustrated the effort. In 1994, as part of a renegotiation of contracts with *State Water Project* customers, the bank was *sold* to the Kern County Water Agency, which *paid* for the bank by giving up 55.5 Mm^3 of its entitlement and agreeing to negotiate additional exchanges with the project's urban customers.

In Southern California's fast-growing, urban San Bernardino and Riverside counties, where demand is expected to increase greatly in the coming years, federal and local agencies are examining the potential for water banking, and trying to figure out how to best avoid contaminated aquifers. Computer models can help managers develop strategies for making the best-coordinated use of surface water and groundwater resources. For example, the desert Mojave Water Agency is investigating ways to use the Mojave River drainage as a recharge area to store surface water in wet years for use during dry years.

Conjunctive use is seen as one way to maximize water supplies so that less water is diverted from streams in dry years. Similarly, making better use of groundwater basins to store water and meet drought year needs is playing a central role in efforts to restore the Sacramento-San Joaquin River Delta (Delta), and minimize the environmental consequences of fresh water diversions in dry years.

But as conjunctive use evolves from a local option into a statewide option for evening out the disparities between wet and dry years, the strategy takes on the controversies of more traditional water supply projects. In particular, Northern California's Sacramento Valley communities that rely on groundwater to meet urban and agricultural needs are wary that plans to restore the Delta with conjunctive use will result in additional water exports that could diminish locally available water supplies.

Some water managers believe the pressures to better coordinate surface water and groundwater will increase pressures for uniform statewide regulation of groundwater. Others believe that as all water sources become more valuable, landowners who previously resisted efforts to determine groundwater rights will find it in their best interest to see those rights defined.

While groundwater management in the past has focused on limiting pumping or recharging aquifers, increasingly management means protecting the groundwater from contamination and cleaning up supplies so they can continue to be used to quench California's growing thirst.

Traditionally treated as two separate resources, surface water and groundwater are increasingly linked in California as water leaders search for a way to close the gap between water demand and water supply. Although some water districts have coordinated use of surface water and groundwater for years, conjunctive use has become the catchphrase when it comes to developing additional water supply for the 21^{st} century.

Recognizing the need to explore conjunctive use projects, the Association of Ground Water Agencies (AGWA), with the assistance of the Water Education Foundation, released a conjunctive use report in late 2000 that identifies the potential to store 26,500 Mm^3 of water in groundwater basins from Kern to San Diego counties. The state-federal plan to restore the San Francisco Bay-San Joaquin Delta includes a goal of implementing enough conjunctive use projects to create 616.7 Mm^3 to 1,200 Mm^3 of additional water storage. And in spring 2001, the Metropolitan Water District of Southern California announced that it had awarded US$ 45 million in state bond monies to nine regional conjunctive use programs that will yield approximately 78.9 Mm^3 of water during dry years.

In its survey of some 85 groundwater basins, AGWA determined there is the potential to store an additional 26,500 Mm^3 of water underground –enough water to fill the region's largest reservoir, Diamond Valley Lake, 26 times. Storage, however, does not equal yield and one of the most critical issues to be addressed is how much and at what rate water can be extracted from a recharged groundwater basin. AGWA's estimate of the increase in annual yield from all of these potential storage sites at 1,600 Mm^3.

In its report, *Groundwater and surface water in Southern California, a guide to conjunctive use*[1], AGWA listed 14 benefits of conjunctive use, including: water quality improvement; water supply reliability; decreased dependence on imported water in dry years; less surface storage required; greater flood control; low evaporation losses; better timing of water distribution; and greater opportunities for conservation.

Potential problems, however, were not ignored. Included on AGWA's list: groundwater overdraft and subsidence; seawater intrusion along coastal aquifers; pollution; and more complex management challenges.

How much new water such projects will ultimately generate is a matter of some debate, and the Foundation has held a number of public briefings discussing this issue. But what is agreed upon is that managing a groundwater basin in conjunction with a surface water supply can greatly enhance water supply reliability.

For example, dry weather conditions in 2001 resulted in only a 35% supply for *State Water Project* urban and agricultural contractors. The ability to tap a local source of groundwater in such periods can help a district cope with such drought-related cutbacks. Conjunctive use projects, in effect, allow water purveyors to meet the constant demand for water despite the state's variable hydrology.

The idea of developing more underground storage has gained broad political support from all water stakeholders –including environmental groups that are opposed to the proposed new surface storage reservoirs.

Each conjunctive use project, however, is different, with its own set of legal, political and technical challenges, and some question how much new water such projects will ultimately yield.

Where do you get the surface water to store in a groundwater aquifer? How do you determine a groundwater basin's safe yield? How long will it take to extract the groundwater? What about overlying owners' rights to the native groundwater? How do you protect the quality of that native underground supply? And in light of the current energy crisis, the costs to run groundwater pumps and recover the stored water joins the long list of issues that must be addressed as local districts, regional forums and state officials pursue plans to increase conjunctive use.

Some of these issues may prove more difficult to resolve than others. Perhaps the biggest challenge –although a somewhat intangible issue– is the question of trust. Trust in the technical information regarding an asset that is highly valued, but hidden. Trust in the experts who suggest that there is sufficient water to pump down the water table without significant impacts. Trust in the idea that water artificially recharged into a groundwater basin will not contaminate the native water. Trust that the groundwater overlying users have relied on for years will be there –even as others extract the new water.

At the core of any conjunctive use project is a concept many in California have resisted –groundwater management. For a conjunctive use program to succeed, water must be measured and managed as it is extracted from and/or recharged into a groundwater aquifer. Yet managing a groundwater basin, to some, equals a state-dictated system for a resource that has, historically, been considered a property right of overlying landowners. And while the state's surface water system is devoted to the concept of moving water from areas of plenty to areas of need, proposals to transfer groundwater from one area of the state to another invite suspicion.

[1] Published 2000 by the Association of Ground Water Agencies (AGWA). Montgomery Watson Americas Inc. and Water Education Foundation. 13 pp.

3.1 *Madera Ranch: what went wrong?*

One proposed conjunctive use project in the San Joaquin Valley –Madera Ranch– serves as a case in point. This was a case where suspicion grew because no local support was developed for the proposed groundwater management program. The local community did not see that they benefited from the proposed program.

Madera Ranch comprises 55 km^2 in Madera County about 32 km northwest of Fresno. Initial analyses indicated that some 370 Mm^3 to 493 Mm^3 of aquifer storage existed here, and in 1998 the property owner and the US Bureau of Reclamation attempted to develop the site as an aquifer storage and recovery project. As proposed, water would have been taken from the Mendota Pool and delivered to Madera Ranch through a two-way canal for recharge in years when excess surface water was available. This water would have been stored underground, extracted in dry years and conveyed via the two-way canal back to the Mendota Pool for distribution.

Local community members feared that water recharged into the depleted aquifer for later use would contaminate the native groundwater in their neighboring wells. There also was deep concern that as water banked in this aquifer was later withdrawn, it would draw down their wells –reducing their water supplies and increasing the costs to pump it to the surface. These fears led to intense opposition from area landowners, politicians and water districts. These community members and leaders said the feasibility study of the project was inadequate to address all their technical concerns. Eventually, the Bureau of Reclamation dropped the proposal, and in 1999, Madera County adopted a new groundwater ordinance that requires a permit to create a water bank and export water from that bank outside the county.

Concern among local landowners resumed after Azurix Corp., a subsidiary of Enron, purchased the Madera Ranch site for US$ 31 million and announced plans for a new water bank. In a February 2000 press release, Azurix publicized Madera Ranch as "an example of an innovative resources project which has considerable potential for both the community and for the company". Azurix is one of several private companies that have entered the California water world in recent years in an effort to profit by marketing water. To mend fences with project opponents, the company offered Madera County 10% to 20% of the banked water and initiated additional studies of the site to address opponents' concerns. But it was too late. Local community members still were afraid that the project would harm them economically. There was no trust.

3.2 *Semitropic: what went right?*

The *Semitropic Groundwater Storage Project*, which like Madera Ranch is located in the San Joaquin Valley, is an example of a successful conjunctive use program in operation for seven years. During the planning and implementation of this 1,200 Mm^3 program, Semitropic Water Storage District officials faced a number of challenges that had not been addressed in conjunctive use projects before. Although environmental issues were relatively easy to overcome, local understanding and acceptance of the concept of using a dewatered portion on an aquifer was a significant hurdle. There was no precedent for this type and size of project.

Because groundwater basins seldom follow district boundaries, Semitropic not only had to gain local approval of the underground bank, but also the acceptance of the other water districts that surround Semitropic. Officials forged this acceptance by launching an extensive *coffee shop* education campaign and establishing a formal groundwater monitoring committee with the neighboring districts. This committee monitors the quality and quantity reports on the groundwater within the basin to ensure that the program does not cause negative impacts to their portions of the groundwater basin.

In the end, it was recognition on the part of local water users –and trust– that they would benefit from groundwater banking that allowed Semitropic management to proceed with establishing partnerships with water suppliers throughout the state to offer a new service –provider of water in drought years.

Since 1986, groundwater levels in this Kern County district, located at the southern end of the San Joaquin Valley, had dropped between 21 m/yr and 24 m/yr. By contracting with outside agencies such as the Metropolitan Water District of Southern California to bank water in its depleted underground aquifer, Semitropic has been able to increase these groundwater levels, reducing pumping (extraction) costs for local users by decreasing the pumping lift. The money these agencies pay to store water in Semitropic helped the district finance the costs of the additional groundwater recharge, recovery and monitoring infrastructure for the groundwater bank. To date, some 740 Mm^3 has been deposited in the bank through *in-lieu* and direct recharge. In addition to Metropolitan, three other public water agencies, the developer of a new subdivision, and a private water company have signed contracts to store certain amounts of water in Semitropic.

Described as a *win-win* program, the contracting outside agencies gain a source of water supply for use in a future drought; 2001, a dry year, brought the first withdrawals. But getting the water out has not been as easy as getting the water in. Right now, the configuration of the bank limits extractions to about 112 Mm^3/yr. Recognizing the need to expand both recharge and extraction rates, Semitropic wants to bring a new well field on line to boost extraction to at least 357.7 Mm^3/yr.

As Semitropic weighs expansion of the project, water quality concerns have become a major problem for the program –the site for the 65-well expansion has problems with naturally occurring arsenic. Because of this naturally occurring arsenic in this well expansion area, as water is recharged into the ground, it will pick up the arsenic. This, in turn, will mean the recovered water (extracted for later use) could have too high of arsenic to meet drinking water standards –especially to convey through the *State Water Project* California Aqueduct, which Semitropic routinely uses to move the water around. Arsenic removal would add to the operation costs of this groundwater banking program and so far the state has balked at Semitropic's proposal that this water not be treated until it reaches the extracting agency's treatment plant. As questions of who should pay remain under debate, Semitropic officials say future restrictions on the quality of water removed from groundwater storage and then introduced in the aqueduct may ultimately eliminate this conjunctive use groundwater storage project as a source of reliable water in a drought year.

3.3 *Successful regional partnerships*

The Foundation also has followed regional conjunctive use programs that are being developed throughout the state to address a wide variety of issues, including projected population growth, environmental protection and improved water quality. The development of trust between the different entities is very important to the success of these regional programs to share water resources. In many cases, years of background meetings to establish common ground and understand other party's viewpoints preceded work to develop specific water plans and programs.

In July 2000, a historic peace agreement was reached in Southern California's Chino Basin, resolving some 25 years of fighting as the stakeholders moved forward with the Optimum Basin Management Program. The accord reached between the area's cities and dairy farmers will allow for the expected and inevitable growth that is predicted to increase population from some 850,000 people to 1,300,000 people over the next 20 years. During that same time frame, the county's historic agricultural uses are expected to decrease more as dairy farmers move to other locations. The water they use, in turn, will revert to the cities.

Stakeholders within the basin include more than a half-dozen cities, several municipal water districts, a variety of non-agricultural industries and dozens of water districts and water companies. Their goal is to create a balanced solution that would meet the future water needs of farms, businesses and residents, as well as the environment and water quality of the Santa Ana River. (The Chino Basin plan is part of the larger *Santa Ana Watershed Project* Authority's conjunctive use program and was one of nine regional projects selected by Metropolitan Water District of Southern California for grant funding).

In the Sacramento metropolitan area, a long list of stakeholders met regularly over the course of six years to reach agreement on the future water use and protection of the region's surface water and groundwater resources. The Sacramento Water Forum, which forged a master water supply plan to the year 2030 as well as a program to preserve the ecosystem of the lower American River, is a model of a collaborative process.

One component of the landmark agreement reached in 1999 is the *Sacramento North Area Conjunctive Use Program*. Under this program, in wet years, the 17 cooperating agencies agreed to reduce groundwater pumping and use water from the American and Sacramento rivers instead, allowing the basin to recharge (some direct recharge also may occur). In dry years, in turn, these agencies will draw more heavily upon water stored underground, allowing more river water to flow downstream to protect the ecosystem of the lower American River.

The Sacramento North Area Groundwater Management Authority, a joint powers authority comprised of the city and the county of Sacramento, the cities of Citrus Heights and Folsom, and several local water purveyors, was formed to manage the basin north of the American River consistent with the Water Forum framework.

4 THE ROLE OF EDUCATION IN GAINING TRUST IN GROUNDWATER MANAGEMENT DECISION MAKING

California and water: the two always have been, always will be, inextricably linked. No resource is as vital to California's urban centers, agriculture, industry, recreation, scenic beauty and environmental preservation as its *liquid gold*.

And no resource is as steeped in controversy. Throughout California's history, battles have been waged over who gets how much of this precious resource. While the echoes of rifle shots and dynamite explosions are part of the state's distant past, the fight continues today in courtrooms throughout the state and on the floors of the state Legislature, the USA Congress. The central reason for the continuing conflicts rests on one overall question: how do you accommodate historical water rights and use to meet modern-day demands? With much of the traditional water development shelved by environmental and economic concerns, reallocation has become the watchword. But reallocation to the new use (primarily urban growth) may bring irrevocable harm to the old use (primarily irrigated agriculture). Add to this clash the ever-increasing political and legal weight of the movement to provide water for the environment and the end result is a precariously balanced three-legged stool –there is no consensus on who should get how much water, but no one interest has enough political power to get its way.

This political realism led in the 1990s to a new movement in the California water story –a movement based on developing a collaborative, consensus-based solution that somehow strikes a balance between providing water for the environment *and* the state's economic engine. It is still very much a movement in its infancy as people try new ideas, new alliances, new thinking.

The base for such a process to succeed is trust. It is vitally important to get people from these competing viewpoints to trust each other. To trust in the scientific and technical information developed.

And the key to beginning any collaboration process is to listen to viewpoints that are not your own. The Foundation fills this niche by providing solid, factual analysis of various water topics through its six annual issues of *Western Water*. This well-written magazine provides a journalistic-style article devoted to issues such as drought, endangered species, water and growth, agricultural water use and drinking water challenges with quotations and viewpoints of the agricultural, environmental and urban groups. As one of the only nonpartisan water organizations in the USA, the Foundation was the first to feature balanced panels of speakers at conferences and briefings; all too often environmentalists attended conferences dominated by environmental speakers and water purveyors attended conferences dominated by other water purveyors, everyone, it seemed, was preaching to the choir.

The Foundation has carried forward this effort to provide a balance of viewpoints in all of its programs, including the groundwater education program it initiated ten years ago. Foundation staff began the program educating people about the state's groundwater resource with development of a 20-page *Layperson's Guide to Groundwater*. The guide explains how much groundwater California has and has access to, groundwater law, groundwater overdraft, groundwater pollution and groundwater management. Accompanying the guide is a poster of the State of California that shows where the groundwater aquifers are located. Cutaways on this illustrate the problems associated with saltwater intrusion, groundwater contamination, and groundwater overdraft.

Both the poster and the guide emphasize that groundwater does not exit in underground lakes, but in the pore spaces of soils and openings in geologic formations. Such concepts are hard to explain, however, because one cannot see groundwater. To assist students, laypeople and even policy-makers in understanding the nature of groundwater, the Foundation produced a Plexiglas groundwater model. By filling this model with water and food coloring, one can demonstrate the effects of groundwater pumping on the quantity of water within an aquifer, and how pollutants can be pulled toward a drinking water well. The model has been widely used for such demonstrations at local city council and county board of supervisors meetings and legislative forums, and in classrooms.

Written materials and models, however, are no replacements for the ultimate teaching tool –a firsthand look at groundwater use. Since 1996, the Foundation has taken groups of stakeholders on three-day tours of groundwater sites in Southern California and in Northern California. The tours allow participants to learn about groundwater basin management issues such as recharge of groundwater aquifers, clean up efforts of contaminated groundwater, seawater intrusion in coastal areas, and conjunctive use of surface water and groundwater. Participants also have the opportunity to hear directly from officials, private citizens and water managers involved in these groundwater issues. Speakers who address these bus tours are balanced among the various interest groups and help participants understand their point of view of the value of groundwater.

Again recognizing the limits of written materials, the Foundation in 1999 used computer graphics in two short videos to explain the complex nature of the state's groundwater resource, and water quality concerns. These videos again show people what groundwater is, how it is pumped to the surface, how it is used, how it can be contaminated and how it must be protected from surface pollution.

Members of the media also use these materials. Water in California and the West is a highly politicized issue, with competing stakeholders often in conflict over how water resource issues should be resolved. Most members of the public obtain their information on these controversial water issues from newspapers and local television newscasts, so it is especially important that the media understand these issues. And because the Foundation is widely recognized as a reliable source of factual, nonpartisan information about groundwater, journalists have come to rely on these materials to help them understand the background of these sometimes highly technical issues and the context of current-day issues.

The various stakeholder groups, meanwhile, know that participating in a Foundation conference or tour will give them the opportunity to network with others from other groups, and trust that the Foundation has no agenda –hidden or otherwise– in any particular solution.

4.1 *Effective educational partnerships*

To extend our reach and effectiveness in the USA, the Water Education Foundation has formed a partnership with the Groundwater Foundation, a national non-profit foundation dedicated to the protection and wise use of the USA's groundwater. The Water Education Foundation is actively involved in the Groundwater Foundation's *Groundwater Guardian* program.

This program supports, recognizes, and connects communities taking voluntary steps to protect groundwater. Groundwater Guardian communities form teams representing citizens, business, agricultural representatives, educators and local government officials. These teams develop activities to tackle the community's groundwater protection concerns. As a program operating on the local level with local people, the programs are often effective in accomplishing goals of education or community action. If the chosen activities are performed to the standards of the Groundwater Foundation, the team is given the Groundwater Guardian shield to display in the community.

4.2 *The importance of school education*

"The philosophy of the school room in one generation is the philosophy of the government in the next". This quote by USA President Abraham Lincoln in the 1860s illustrates the important role our school education program plays in our effort to increase the public's understanding of groundwater issues.

In addition to encouraging teachers to use the groundwater model in their classrooms, the Foundation includes lessons on groundwater in its education *curricula* for all grade levels. For students in grades 7 through 10, the Foundation developed the 18-unit *Groundwater Education for Secondary Students curriculum*. The lessons are designed to teach students these important concepts: What is groundwater? What is an aquifer? How are groundwater and surface water connected? How is water discharged and recharged in an aquifer? And why it is important to conserve groundwater, and how to protect aquifers from pollution. Two of these lessons are available in Spanish.

Groundwater pollution caused by the gasoline additive MTBE (methyl tertiary butyl ether) is the focus of a curriculum for students in grades 8 through 12. *MTBE Risks and Issues: setting taste and odor drinking water standards* teaches students about MTBE as a drinking water contaminant through discussions of the physiology of taste and odor, how taste tests are conducted, how drinking water standards are set, and the role of science in public policy. This program was developed by the Civil and Environmental Engineering Department at UC Davis, and edited and formatted by the Foundation.

Many of the state's 50 county offices of education have hosted Foundation workshops with these and other school programs. As the California coordinator for *Project WET* (*Water Education for Teachers*), a national water education organization, the Foundation's education director reached over a half-million students in 2001.

Recognizing the need to educate students about water quality issues, the Foundation created a nonpoint source water pollution board game, the *No-Know Game*, to explore the types of common activities that contribute to groundwater pollution.

5 FINAL THOUGHTS

As we have discussed, groundwater management in California is largely subject to local control. Periodically, efforts are made to establish a more state-centralized system. To date, such efforts have met with political defeat, leading many –including the Foundation– to work toward better management of the groundwater resource through existing law and values –better local management.

With water at a premium in the Golden State, there is increasing interest in better coordinating the use of surface water and groundwater to further stretch the total supply. Such a conjunctive use system requires the buy-in from local communities and local groundwater users. Those who champion conjunctive use, however, must focus not only on establishing a solid technical program, but a solid political program as well. Local communities must see that the project will provide them with local benefits, and project proponents will need to spend a significant amount of times fostering the development of trust between the different stakeholder communities, the beneficiaries of any project, and the local community that relies on the groundwater aquifer. The nonpartisan Water Education Foundation has received national recognition for its work in bring stakeholders and the public to an understanding and involvement with water resources in the Western USA. Although the impacts of our programs are sometimes difficult to quantify, the Foundation can tell through attendance at symposia and tours, the sale of these low-cost materials and the letters and phone calls received that the Foundation has played an important role in helping people better understand the complexities of water resource issues in California and the Western USA –including groundwater issues.

The Foundation's success also has been recognized through state and national awards, the many federal and state grants we have been awarded, and the partnerships we have forged with stakeholders on all sides of these issues. Through its nearly 25 years in existence, the Foundation has changed the very nature of how the main competing stakeholder groups –agricultural water users, cities and urban water providers, and environmental and conservation membership organizations– communicate. Many of the leaders in all of these sectors have thanked the Foundation for helping them better understand other points of view and recognizing important areas where there are common goals. Formal partnerships between these groups and informal exchanges of ideas have been the result –with the seeds for many of these efforts sowed by participation in the Foundation's activities and the review of draft publications and other materials.

One reason the Foundation has been successful is due to its continuing responsiveness to the needs of stakeholders and the public. The Foundation, through its many education programs, including its groundwater education program, is committed to using education for problem solving in this important area. The interdisciplinary programs developed by the Foundation and the issues covered and illuminated by the Foundation in its publications and other programs are leading to informed decision making on groundwater issues.

By informing stakeholders and the public on groundwater issues, the Foundation has made great progress in designing education programs and materials that address the changing groundwater issue. The lessons learned by the Foundation could be valuable for governmental and nongovernmental organizations working in other parts of the world. The core issue of education and responsiveness to the search for knowledge and information of key audiences is a universal need.

SOME USEFUL PUBLIC EDUCATION WEB SITES

– American Water Works Association: www.awwa.org
– Audubon Wetlands Campaign: www.audubon.org
– East Bay Municipal Utilities District: www.ebmud.com
– GREEN-Global Rivers Environmental Educational Network: www.green.org
– International Rivers Network: www.irn.org
– Mono Lake Committee: www.monolake.org
– Rivers Project: www.siue.edu/OSME/river
– UNICEF: www.unicef.org/programme/wes
– Water Aid: www.wateraid.org.uk
– Water Education for Teacher WET Project: www.montana.edu/wwwwet
– Water Education Foundation: www.watereducation.org
– Water Environment Federation: www.wef.org
– Water Wise and Energy Efficient Program: www.getwise.org

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SECTION 4
Regional and national issues