

Alchemy or Salvation? Desalting the Sea

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From *Whose Water Is It? The Unquenchable Thirst of a Water-Hungry World*

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San Diego gets very little rain, but it is home to 2.7 million people, and it is growing fast. It owes its beauty to the Pacific Ocean but its survival to its neighbors within the state and outside it, who provide 86 percent of its fresh water, most of it from the Colorado River. But now the county is getting ready to turn to the sea in a much bigger way, seizing on the ocean as "the world's largest reservoir." By 2007, if all goes as planned, the water utility will begin producing desalted seawater at a rate of 50 million gallons of fresh water a day, at a \$270 million desalination plant that will become the hemisphere's largest. That will supply about 8 percent of the county's water needs, a leap forward toward a future in which some believe American and even worldwide water needs will be sustained by the oceans in ever greater measure.

As recently as 1993, San Diego had rejected desalination as too expensive. But with prices dropping fast, it is not the only place where seawater is winning converts. In Tampa, Florida, what is now the hemisphere's largest seawater desalination plant opened in March 2003. Its costs of producing fresh water from the ocean are lower than any other in the world, and along with San Diego, more than a dozen other communities in Florida, Texas, and California are hoping to follow suit. For the first time, seawater desalination efforts are winning funding from the state and federal governments; in New Mexico a national laboratory is searching for even more effective ways to make the sea drinkable. Over the next 10 to 15 years the Metropolitan Water District of Southern California, one of the largest in the country with 19 million customers, has set a goal of producing 150,000 acre feet of desalted seawater a year-enough for 300,000 households, or 1.2 million users, which is about 7 percent of its customers' needs. "Desalination is no longer on the lunatic fringe," said Barry Nelson, an expert at the Natural Resources Defense Council, an environmental group. "It has entered the mainstream."

Will Tampa and San Diego really set the mold? Can seawater desalination mean salvation from water woes? Or is it instead akin to alchemy, with more glittering potential than practical applicability, except in places where desperation and bad planning have left no other choice? Might more mundane solutions-like using more water again and again instead of trying to manufacture new supplies-be more cost-effective and prudent?

To weigh those prospects requires some thinking about the past and present. Certainly, the need for more fresh water has become acute. In supplying regions closest to the coast where energy costs are low, seawater can compete with other options. But so can solutions that reuse existing fresh water instead of manufacturing it, and those less glamorous approaches may be the most promising.

Consider, for example, the discomfiting picture painted by Steve Malloch of the Western Water Alliance, a coalition of conservationists, water users, and state officials. "In years of average precipitation," he writes in "The Western Way of Water," a June 2003 report, "water supplies in most of the West are already more than fully used. We get by because the West's major lakes and reservoirs help store some of the water from year to year, allowing wet years to help meet the needs of normal and dry years." That is an undeniably fragile architecture; when wet years become fewer or more widely spaced, as during the recent drought (or possibly the impact of global

climate change), the whole system faces collapse. But to what extent is seawater the solution?

One place to start is southern California, where planners have had to confront more directly than in any other state the prospect that water supplies might not be sufficient to sustain its people. Like San Diego, California and southern California in particular has become a victim of its success, incapable without outside help of sustaining even a tiny fraction of its current population. As it tries to expand its supplies, from a base that comes primarily from northern California and from the Colorado River, it is only natural that the Metropolitan Water District is turning to the ocean.

But it is also worth keeping in mind that water is not necessarily consumed in the way that, say, food or electricity is consumed. Often what is pumped from an aquifer or siphoned from a stream ends up back in the same system, having passed through showers, washing machines and toilets, drains and sewers. The use of so-called gray water for watering or even drinking has become increasingly common, and it offers water managers another option for creating new water. In future plans, reused water will play an even larger role than seawater even in southern California, where projects that the big water district helped to fund in 2002 produced 75,000 acre feet of water. (An acre foot of water, the industry standard, is about 326,000 gallons, or the amount that two urban households consume in a year.) Combined with the 126,000 acre feet in reused water produced by its members without the district's financial assistance, the total of about 200,000 acre feet right now is more than the district hopes to produce from desalination a decade or more from now. The U.S. Bureau of Reclamation has identified another 34 projects that it says can yield more than 450,000 additional acre feet in the next few decades. That represents a real water source, not just a novelty; by using gray water for outdoor watering or collecting runoff, for example, water managers can add to supplies and minimize the need to seek out new sources.

The major exception is water used on crops, most of which disappears through evaporation and by passing through the roots. In California, for example, according to statistics assembled by the U.S. Geological Survey, agriculture accounts for 64 percent of water withdrawals but 93 percent of the water consumed. That means water shifted away from farms could have a disproportionate impact, because it would free up water that now is used only once but could be used again and again in efficient municipal and industrial systems.

Indeed, in southern California, the water district has made a major effort to buy up water from farms, particularly in the Imperial Valley, whose disproportionately huge title to most of the state's allotment of Colorado River water has long rankled the coastal cities. But the district has also concluded that they should at the same time try to tap the sea. The fact that Tampa, not San Diego, was the first large American *city* to turn to desalination offers a hint to the option's appeal.

Unlike southern California, central Florida is a region of abundant rain, with some 30 inches of precipitation a year. Tampa had acted for years as if its water sources were limitless, enough to serve a population whose explosion showed no signs of slowing down- As with most of Florida, nearly all Tampa's fresh water comes from underground, which made the illusion easier to sustain. But by the mid-1990s, groundwater pumping had begun to take an undeniable toll that could be measured in sinkholes, dying trees, and saltwater intrusion into freshwater aquifers. Under pressure from the courts, the Southwest Florida Water Management District promised to cut back on its pumping and shift away from what was proving an unsustainable course. Yet rivers, creeks, and reservoirs offered no real alternative. Although the sea is a source of last resort for drinking water, Tampa has embraced it. Since March 2003, the

plant in Tampa has been sucking about 44 million gallons of seawater a day from the Gulf of Mexico, to produce about 25 million gallons of fresh water - about 10 percent of the water used by Tampa's nearly two million people.

Still, the Tampa plant needed several years to win approval from state regulators, caused by opposition that is a reminder of the misgivings still facing such projects. Even the most advanced desalination systems, like the one in Tampa, require about 1.8 gallons of seawater to produce a gallon of fresh water, leaving a briny by-product that must be disposed of. One concern has been that the release of briny water, twice as salty as the sea, could have a harmful effect on the underwater ecology. In Tampa, critics said *they* feared that desalination would result in a saltier Tampa Bay, with possible harm to water life, including some fish and perhaps the manatee, an endangered marine mammal. But several studies have suggested that the concerns are misguided. A study commissioned by Tampa Bay Water found no reasonable risk that salinity in the bay would build up over time. The research found that the estuary into which the outflows would be pumped already flushes naturally, and it pointed out that native species of fish and sea grass are already accustomed to salinity variations. But some independent experts have been more skeptical. Although the water discharged back into the bay is to be diluted with ordinary seawater, at a ratio of 70:1, the effects are being closely monitored, and indication of harm will almost certainly prompt a legal challenge.

Aesthetic concerns also posed an obstacle. Unlike a reservoir or a groundwater pump, a desalination plant is neither attractive nor easily hidden, and its neighbors, who organized themselves into groups with names like Save the Bay, were united in trying to keep a desalination plant out of their backyards. Only through an unusual process, in which a regional coalition had the power to override objections from the county that is home to the desalination plant, was the plant able to win political approval.

But the most important obstacle was financial. To promote desalination as an alternative to the groundwater pumping, the regional water authority put up 85 million dollars of \$110 million in construction costs. But a private consortium that was to have owned and operated the plant found itself unable to win the financing it needed, and the water utility had to buy the project itself so that it could go forward. Production costs have turned out to be much lower than the \$4 to \$6 a gallon that was initially projected, and the cost of about \$2.49 per 1,000 gallons remains the lowest of any desalination plant now in operation or planned. Because of the subsidy from the water district, the wholesale cost will be even lower, about \$1.88 per 1,000 gallons.

That is less than any other seawater desalination plant now operating, in part because Tampa Bay, with its numerous freshwater inflows, is less salty than most oceans. Still, compared with more conventional methods of acquiring water, the costs are staggeringly high. They are nearly double the one-dollar-per-1,000-gallon cost of the groundwater on which Tampa had previously relied. Seawater desalination is not the only new source of water on which Tampa is relying, and all are expensive. They are expected to gradually drive up the wholesale water rate to between \$2.34 and \$2.91 per thousand gallons, up from \$1.75 in 2003, a cost that will be passed on to customers.

Until Tampa took the plunge, only two American cities had invested in full-fledged seawater desalination plants - Key West, Florida, in the early 1980s, and Santa Barbara, California, a decade later. Both of those cities shut down their operations soon after they began, having lined up cheaper alternatives; their plants are now maintained to provide emergency backup. "It's still cheaper for us to pump fresh water 130 miles down here from the mainland than to make it from sea

water," Jim Reynolds, deputy executive director of the Florida Keys Aqueduct Authority, told the *New York Times*. Those experiences should be interpreted as reasons for caution; desalination is not necessarily for everyone.

The largest seawater desalination plants in the world, and by far the heaviest concentration, are located in Saudi Arabia, Kuwait, and other countries on the arid Arabian Peninsula, whose supplies of fresh water are so scarce that desalination is essentially the only alternative. Saudi Arabia, for example, with no year-round rivers and only limited and rapidly disappearing groundwater, produces 70 percent of its fresh water from the sea, and pipes much of it long distances from the coasts on the Red Sea and the Persian Gulf to cities in the interior like Riyadh, the capital. Until recently the combination of desperation, wealth, and cheap energy has generally been regarded as representing a rare constellation of ingredients in which desalination might make sense.

The basic process isn't new; military vessels and cruise ships have relied on desalination for years. Worldwide, more than 13,000 desalination plants are in operation, producing 6.8 billion gallons a day. The largest, including one in Yuma, Arizona, tend to be those that purify brackish water, usually from underground, a process that is cheaper and easier than leaching salt from the far more saline seas. Most such plants can get away with systems that rely on heat, evaporation, and distillation. But seawater generally requires more, in technology and expense.

Remember high school science and osmosis, in which two bodies of water with different amounts of salt or other minerals will equalize in concentration? The most widely used process for seawater desalination uses reverse osmosis to accomplish the opposite, requiring 100,000 pounds per square inch of pressure as the seawater is pumped into plastic membranes through which salt and other molecules cannot pass. The reverse-osmosis membranes today cost half as much, last twice as long, and are twice as productive as membranes manufactured ten years ago, which is one reason that the price of the process has begun to drop. The other essential components are energy (to create the pressure) and a pipe infrastructure (to siphon water from the sea and return the discharge).

One lesson from Saudi Arabia has been that costs can be reduced when the desalination plant is built next to a coastal power plant, which provides cheap electricity and already relies on seawater for cooling. Nearly every seawater desalination plant now being planned or built, including those in Tampa (next to Tampa Electric Co.'s Big Bend plant) and San Diego County (next to the Encina Power Station, in Carlsbad, California), follows this model, including the use of power pump pipes and creating the arguable aesthetic benefit of putting one coastal eyesore next to another.

The widespread expectation is that the desalination market will increase quickly in coming years. Tampa, for one, is talking about building a second desalination plant; in California, as many as a dozen plants are expected to begin operations over the next ten years; nine water districts in south Texas have submitted proposals to meet increasing demands. In the United States today, the market for desalination plants and equipment is merely two billion dollars, but it may well grow to more than seventy billion dollars over the next two decades, according to the American Water Works Association, a major industry group. One of the biggest companies involved is Poseidon Resources, a privately held concern that was the lead developer on the Tampa Bay project, and which is also working on projects in San Diego and Huntington Beach, California, and Freeport, Texas.

What has changed, apart from the fact that desalinating seawater has become cheaper? One factor, as Adan Ortega, Jr., a vice president of the Metropolitan Water District of Southern

California, put it, is that its alternatives as new sources of water have all become more expensive. The price of pulling water from existing reservoirs and streams is a tiny fraction of desalination.

But if it is possible at all, building new dams, pumping from new aquifers, or tapping existing rivers is becoming prohibitively expensive because of scarcity as well as regulatory and environmental hurdles. In one sign of public readiness to pay a price for desalination, California voters in November 2002 approved state funding for such efforts. That has allowed the Metropolitan Water District to back up its advocacy with money, by offering water districts like San Diego's subsidies of up to \$250 per acre foot.

But even such a subsidy would go only a small *way* toward helping out with the price tag. In San Diego, current estimates for the facility planned for 2007 put the cost of desalting seawater at about \$900 an acre foot, or \$2.76 per 1,000 gallons. That is more than the cost at the older plant in Tampa, in part because the Pacific is saltier than Tampa Bay, and in part because Florida is flatter than southern California, reducing distribution costs. (Uphill pumping makes seawater desalination a solution primarily for the coasts. The projected cost of desalinated seawater in San Diego is also nearly three times greater than the price of the transfer the county has negotiated with Imperial Valley farmers, and higher as well than some other options, including conservation and expanded groundwater production. Still, Bob Yamada, seawater desalination manager for the San Diego County Water Authority, argues that desalination makes sense, in part because it will "provide us with a new, local, high-quality, drought-proof supply that will help us to diversify our water-supply portfolio." No matter how little rain falls, no matter how much the levels of reservoirs, aquifers, and rivers drop, the ocean will be there.

Like most American communities, San Diego has been forced in recent years to confront its water future, and its projections look very different from the past and present. According to the Water Authority's current projections, demand in San Diego County will soar by about 33 percent by 2020, to 813,000 acre feet a year. The current blueprint calls for meeting it through a large shift away from imported water to local sources, and seawater (up from 0 percent to as much as 14 percent of supply) looms large among them. But it is important to note, too, that the plan also envisions a big leap in conservation (from one percent to 10 percent of supplies), recycling (from one percent to 6 percent), and the transfer of water from farmlands to the city (from 0 percent to 22 percent), and even increases in local surface water (from 3 percent to 6 percent) and aquifer (from 3 percent to 6 percent) supplies. The goal is greater self-sufficiency, to reduce dependence on others, particularly the over-tapped Colorado River.

Alchemy or salvation? Maybe the better way to think about desalination is instead as just one part of the portfolio, one variable in the troublesome (and increasingly expensive) new balances that people around the world are seeking to strike when meeting water needs. "We live in an era where there is no free water, with increasing uncertainties caused by nature, politics, and regulation," said Adan Ortega, Jr. "The solution is diversity:"

Barry Nelson, the water expert at the Natural Resources Defense Council, put it another way: "There is something primally appealing about turning salt water into fresh water. There is something almost biblical about that. And Americans love whiz-bang technology. But my concern is that too much attention will leave people to forget about things like better shower-heads and more water-efficient gardens. People are not laughing at desalination anymore. But it's not a silver bullet."