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Technology's Promise

Kings highway in southwest Florida stretches from Charlotte Harbor northeast into palmetto scrub and cattle ranches. Until recently, it was a lonely two-lane road with little moving but the solitary red-tailed hawk overhead, the dim-witted armadillo just missing your wheel. Pale blue sky and native grasses made for a wide view, broken only by barbed wire and the occasional makeshift roadside memorial.

The serpentine highway was named, appropriately, for the man considered the "Cattle King" of South Florida, a six-foot-six-tall rancher named Ziba King. But in recent years, the cattle ranches along Kings Highway have fallen one by one. The widened highway now snakes through an entirely different sort of crop: rooftops. Strip shopping centers, banks, and, most of all, middle-class subdivisions fill the horizon. Five thousand new homes are in various phases of construction: concrete slabs here, frames there, real estate signs everywhere. A Super Wal-Mart with gas station and garden center is underway on a 50-acre tract of grassland. Developers are making room, too, for more of the travelers who stream by on Interstate 75—the highway that runs north and south from Detroit, Michigan, to Naples before jogging east across the Everglades. A

La Quinta Inn is going up on one side of a Cracker Barrel, a Sleep Inn on the other.

The development pattern is both familiar and relentless. As Florida's coastline fills up, urbanization marches inland. The farther from the beach, the more affordable the single-family home, the cheaper the hotel chain. Hurricane Charley devastated this corridor in 2004, leaving 10,000 people homeless. Two years later, more than 700 families still lived in temporary housing that residents call "FEMA City," a stark, treeless trailer park adjacent to the interstate. But neither Charley nor the three other hurricanes that walloped the area the same year could slow the moving vans. In fact, the devastating 2004 hurricane season had almost no effect on the following year's population growth. "Florida's population grew by more than 400,000" after the quadruple hurricanes, says Stanley K. Smith at the University of Florida's Bureau of Economic and Business Research. "This is one of the largest increases in Florida's history."[1]

Over the coming decade, Smith's demographers predict, Florida will grow another 21 percent, exceeding 21 million people to become the third-largest state behind California and Texas. Between those residents and upward of 70 million tourists a year, regulators predict total demand for water in the state will climb to 9.3 billion gallons a day.[2] That is a billion gallons more than Floridians use now. With groundwater reserves tapped out in so much of the state, politicians and water managers are desperate for new ways to get water to the sprouting subdivisions. They are turning, increasingly, to high-tech alternatives, such as underground storage wells or saltwater desalination.

This drive to find "new" sources of water is underway across the United States, even in slower-growing states such as Wisconsin where aquifers are overdrawn. The search for new water is no longer solely an urgency of the American West. U.S. senators from both sides of the 100th meridian have forged a coalition to make sure more federal funds are spent on water-supply research and technology.[3] "Despite receiving substantially more rainfall than the western United States, much of the east coast is facing water shortages," U.S. Senator Pete V. Domenici, New Mexico Republican and then-chairman of the Senate Energy and Natural Resources Committee, said as he opened a hearing on new water-desalination facilities in 2005. "Boston, Atlanta and much of

Florida are nearing the end of readily available water. Without significant technological advancements that allow us to better utilize, conserve and produce additional water in a cost-effective manner, it is unclear how we will meet this need."[4]

The emphasis is clearly on producing additional water. Much like they championed dam building in the twentieth century, the Bureau of Reclamation and other federal agencies now push expensive supply-side solutions to solve the nation's water woes. The bureau's "Desalination and Water Purification Technology Roadmap," a joint effort with Sandia National Laboratories, assumes that the United States will require 16 trillion additional gallons of water a year by 2020 for municipal and light industrial use—the equivalent of a quarter of the total outflow of all the Great Lakes.[5] This ignores the nation's decreasing per capita use of water, and the fact that industries, from steel factories to farming, use less and less water as efficiencies improve. In the 1930s and 1940s, for example, it took as much as 300 tons of water to produce one ton of steel. By the 1980s, overall water consumption to produce steel had dropped to between 20 and 30 tons.[6]

The government's roadmap notes that "water saved by conservation programs will be insufficient to slake the nation's ever-increasing thirst." It goes on to say that "conservation activities can also reduce the volume of in-stream flows (by reducing the amount of wastewater returned to the stream) with serious consequences for the environment."[7]

To be sure, desalination and other high-tech solutions will help wean the nation of its dangerous overreliance on groundwater. So will more efficient fixes, such as conservation and true-cost pricing. But if the history of water in the United States teaches anything, it is that engineered solutions are rarely as perfect as their boosters boast. Consider President Herbert Hoover's Cooke Commission on Water Resources, which predicted, in 1950, that the nation's rainfall would be doubled by cloud seeding. (The commission also ignored the water needs of fish, wildlife, and recreation and said the federal government should wait a decade before intervening to control water pollution.)[8] Like the dams and the wetlands-drainage and the dredging schemes of the past, scientific solutions usually come with unintended consequences. One of those can be found deep underground, just a few more miles down Kings Highway.

TROUBLE UNDERGROUND

Not far from FEMA City, after Kings Highway passes under Interstate 75, it narrows back to two lanes heading into Florida's interior. Past a few moderately priced new subdivisions, the land begins to give way to cattle ranches once again. Retail development remains a few years away. For now, the commercial strips between the tract homes are filled mostly with businesses related to the home-building industry: contractors, real-estate agents, land surveyors, engineers. And then, around a big curve, the business most important to the rooftop crops: water supply.

At first glance, the Peace River/Manasota Regional Water Supply Authority looks like your everyday water plant: a pair of huge, blue cylinders to store water and to treat it. But what is interesting about this place is not what you can see—it is what you can't. Deep in Florida's limestone aquifer here lies the biggest underground water-storage project in the eastern United States.

Known as Aquifer Storage and Recovery, or ASR for short, the technology was designed to withdraw millions of gallons of water during wet months and to store it deep underground to retrieve during dry months. The Peace River facility, which stretches across 6,000 acres on both sides of Kings Highway, includes a 600-million-gallon reservoir and 21 wells. Each blue well is surrounded on all sides by a chain-link fence, giving the well field the appearance of a roadside zoo full of pipe animals.

When water is plentiful, the authority sucks 36 million gallons a day from the nearby Peace River, a watershed that begins in Central Florida's Green Swamp and flows south 105 miles into the Charlotte Harbor Estuary. It goes first to the reservoir, then to the treatment plant. Twelve million gallons are saved in the reservoir, 18 million flow to the four fast-growing counties served by the water authority. The remaining 6 million gallons are injected via the ASR wells between 700 and 900 feet underground. There, the water sits in huge bubbles in the aquifer, which acts as a natural underground storage tank. During dry months, the ASR wells work in reverse: sucking the water back up again to meet demand.

The U.S. EPA estimates there are 1,695 ASR wells in the nation, most of those in the water-troubled states of California, Nevada, Texas, and Florida. The Peace River water authority was home to the first ASR well in Florida. It was sunk in 1983, not by the government, but by a home-building company called General Development Corporation, which later went bankrupt.

Miami-based GDC started out as a family business in the 1950s and grew into a $500 million a year conglomerate that was famous for the hard sell. In its heyday, it had a 3,000-person sales force that sold 400,000 lots and more than 30,000 homes throughout the state. The company played a huge role in luring northern retirees to South Florida. But by the early 1980s, GDC was in deep trouble, facing steep debts and investigations into allegations that it cheated customers.[9]

Some employees who worked for GDC's water department back then still work at the now-government-owned Peace River facility. In the early 1980s, GDC's utility company had to expand water supply for its fast-growing southwest Florida developments such as North Port. A reservoir was the logical choice. But a brand-new technology called ASR was available for about a tenth the cost. "They did ASR out of desperation," recalls one employee. "The decision wasn't based on hydrologic data at all. It was based solely on cost."

Turns out, hydrologic data is crucial to sinking a well. That is true for all sorts of reasons, not least of which is the concentration of arsenic in some parts of the aquifer. It is not uncommon for arsenic to show up in groundwater in some parts of the country, mostly through erosion of natural deposits, and sometimes from industrial runoff. Some geologic formations, including some in Florida's aquifer, hold much higher concentrations of it than others.

Arsenic, a metal, is the fifty-second-most-abundant element on the planet, averaging 2 parts per billion (ppb) of the earth's crust. It also can be deadly to humans. The French emperor Napoleon Bonaparte likely died of arsenic poisoning; modern scientists confirmed toxic levels of arsenic in his hair, though they disagree about whether he was deliberately poisoned by his enemies or died as a result of gradual exposure.[10]

The EPA classifies arsenic as a human carcinogen. It can cause skin, bladder, lung, kidney, liver, prostate, and other cancers. It is called an "accumulative enabler" because it makes people more likely to become ill from various cancers, diabetes, and high blood pressure. It may cause cardiovascular, pulmonary, immunological, neurological, and endocrine diseases.[11]

The EPA classifies arsenic at a concentration of 60,000 ppb "immediately dangerous to life or health," meaning if you ingest that much, you will die. Ingestion at levels between 300 and 30,000 ppb may cause stomach pain, nausea, vomiting, and diarrhea. Under the Safe Drinking Water Act, the EPA has regulated arsenic in drinking water since 1976. For twenty years, the highest acceptable level was 50 ppb. In 2000, the Clinton administration proposed lowering that to 10 ppb based on new evidence of increased risks of bladder and lung cancer. After reviewing the proposed change, President Bush's first EPA secretary, Christine Todd Whitman, approved the new standard and made it effective January 1, 2006. (When she was governor of New Jersey, Whitman had lowered the acceptable levels of arsenic to 10 ppb in that state.)[12]

When the standard changed, lots of Florida utilities managers found themselves in a bind. Testing by the state's Department of Environmental Protection revealed that numerous ASR wells in Florida contained arsenic-contaminated water greater than 10 ppb. Some wells far exceeded the previous standard of 50 ppb. How could river water with no trace of arsenic become contaminated during underground storage? Scientists soon had an answer. Arsenic is ubiquitous in the part of the aquifer where ASR wells store water; in Central Florida this is known as the Suwannee Limestone layer. The mix of highly oxidized ASR water with the low-oxygen water that exists in the Suwannee Limestone causes arsenic underground to "mobilize."[13] Hydrogeologists are trying to figure out how to stop it. Engineers believe that running the same water through ASR wells several times will alleviate it. But EPA rules prevent them from serving up water from wells that have tested so high. At an ASR conference in Florida in 2005, scientists and utility directors literally spent more time talking about how to finagle exemptions to the drinking-water standards than they did discussing solutions to the arsenic problem.[14]

The problem proved daunting enough that the Peace River authority backed off plans for a major expansion of ASR wells to supply water to its burgeoning population. Instead, the authority is building a 6-billion-gallon reservoir. It will be ten times bigger than the current reservoir, and cost $55 million. Executive Director Patrick Lehman estimates that is about 20 percent more than new ASR wells would have cost. "I think the science will catch up," Lehman says of the arsenic problem.[15]

"Science will prove sound methods to solve the problem," he says. "The question is when."

In other parts of the nation, too, governments have halted ASR plans over arsenic concerns. In 2003, the Wisconsin Department of Natural Resources stopped the City of Green Bay's pilot project to store Lake Michigan water in ASR wells after tests revealed the underground storage hiked arsenic levels.[16] And arsenic is but one wild card in the ASR deck. The Georgia legislature has placed a moratorium on any ASR wells in the Floridan Aquifer, which underlies southeast Georgia and parts of South Carolina and Alabama in addition to Florida, over concerns that stored water could contaminate the deep aquifer water. Other fears include land subsidence or the fracturing of aquifers.

Despite these uncertainties, the federal and Florida governments maintain an astounding level of faith in ASR technology. It is a cornerstone of the Comprehensive Everglades Restoration Plan now underway in South Florida, representing one-fifth of the estimated $10 billion total restoration cost. The plan calls for 333 ASR wells, which would be the largest use of ASR in the world. They would pump as much as 1.7 billion gallons a day of excess surface water and groundwater during wet times and store it in the Floridan Aquifer to recover during seasonal dry periods or longer-term droughts. Experts, such as a National Research Council panel advising the restoration effort, have raised numerous concerns over whether ASR will work in the Everglades. Those include "suitability of proposed ASR source waters, paucity of regional hydrogeologic information, hydraulic fracturing of the aquifer, impacts on existing wells, water-quality concerns, mercury bioaccumulation and others."[17]

Three pilot studies underway in South Florida over the next eight years will help determine whether the Army Corps and South Florida Water Management District go forward with the ambitious ASR plans. "We still don't have the science to understand what happens when you put that much water in the ground," admits Chip Merrian, deputy executive director for water resources at the district. If the pilot projects prove the area unsuitable for all or some of the 333 ASR wells, he says, the agencies will change course. That is the idea behind "adaptive management," the core philosophy of the thirty-year restoration plan. Scientists and engineers can try something, see how well it works, and then modify it.

Just in case the enormous underground storage proposals fall through, water managers are lining up other ways to get water to the masses crowded onto the southeast tip of the state. South Florida's population is expected to double, from 7 million people today to 15 million by 2050. One option is a mammoth desalination plant somewhere on the lower southeast coast that could make up to 30 million gallons of freshwater a day, about the amount consumed each day by the residents of West Palm Beach. Such a plant could be finished by 2015, water managers say, as much as fifteen years ahead of many of the water-storage schemes in the Everglades plan.[18]

Before they go forward with a plan so bold, they are likely to look closely at how a similarly ambitious one has gone all wrong, just across the state in Tampa Bay.

DESALTING THE SEA

The first time Americans looked to the sea for drinking water was in 1861, at Fort Zachary Taylor in Key West, Florida. The Union army ordered a "Marine Aerated Fresh Water Apparatus" from England, patented by a man named Alphonse René le Mire de Normandy of Judd Street in London in 1853. The huge device, shipped across the Atlantic Ocean to New York and then down to the Florida Keys, sucked salt water from the sea, heated it in a giant boiler, and sent it into towering pipes, where it was evaporated and condensed, leaving the salt behind. Fueled by wood and coal, the apparatus provided 7,000 gallons of freshwater a day to the 500 soldiers who were stationed at Fort Zachary Taylor between 1861 and 1865 to protect the nation from enemies who might attack from the Florida Straits.[19]

Today, Fort Zachary Taylor is a national park, where tourists can learn about the Civil and Spanish-American wars (actually, most people head there because it has the most beautiful beach in Key West). Park services specialist Harry Smid maintains historic documents relating to the desalting apparatus. "You would think," Smid muses, "that if the Union Army could de-salt the sea in the 1860s, that we could do it today."

Easier said, the cliché goes, than done. Wresting salt from the sea was so difficult, and so inefficient, that it would be easier to ship freshwater down from Tampa in barges, which is just what Conchs, the nickname for Florida Keys natives, did later in the nineteenth century.

Still, Floridians would not give up on the dream of putting their vast seawater supply to work. One hundred and fifty years after the army brought what is now known as desalination to the United States, Florida set two more milestones in the history of the technology.

First, it would build the largest desalination plant in the Western Hemisphere.

Then, that plant would become the most spectacular failure of desalination technology anywhere in the world.

In 1961, President John F. Kennedy spoke of the great promise of desalination to solve the global freshwater crisis: "If we could ever competitively, at a cheap rate, get fresh water from saltwater," he said, "that would be in the long-range interests of humanity (and) would dwarf any other scientific accomplishments."[20]

"Cheap" would prove problematic. Instead of solving water crises in those parts of the world where people die each day for lack of freshwater, desalination plants tend to be built by the richest nations. There are two primary ways to remove salt from water. One is Alphonse René le Mire de Normandy's method: heating the water and condensing the steam, which is called "distillation." The more modern technique is to filter the water through a membrane, known as "reverse osmosis," or RO. Both take huge amounts of energy, and for that reason, desalination is by far the most expensive of all water-supply options.[21] That made it the purview of wealthy countries in the Middle East. Energy-rich but water-poor nations have built plants throughout the Persian Gulf.[22] Saudi Arabia is the world's largest producer of desalinated water, with more than thirty plants that provide 70 percent of the kingdom's water supply.

Until the late 1990s, only two American cities had built true desalination plants—Key West and Santa Barbara, California. But costs were so high that both cities shuttered the plants soon after opening them. Today, Key West and Santa Barbara maintain them only in case of an emergency.[23]

As RO technology improved, and as costs dropped, more and more cities around the world began to look to the sea for water. RO proved efficient for desalting brackish waters, too, at lower costs than seawater desalination. By 1998, more than 12,000 desalting plants had been built in more than 120 countries.[24] One lesson they took from Saudi Arabia was this: costs could be further reduced by building a desalination plant next to a coastal power plant, which already sucks up and filters millions of gallons of seawater each day—and which offers inexpensive electricity.[25]

All of this made a city called Apollo Beach, home to Tampa Electric Company's Big Bend Power Plant on brackish Tampa Bay, seem like the perfect place to build the largest desalination plant this side of Saudi Arabia. In 1998, the nearly twenty governments that had been warring over the disappearing groundwater of Tampa Bay declared a truce. They joined together to establish a regional water utility called Tampa Bay Water. The utility is the largest water wholesaler in Florida, selling to utilities in Hillsborough, Pinellas, and Pasco counties that in turn sell to 2.5 million people. The idea was that one big utility could eliminate economic competition for water, and focus on regional supply and conservation planning to slash dependence on groundwater in half. The Southwest Florida Water Management District would help the utility fund new supply as long as it met specific goals for cutting groundwater use over time: from 192 million gallons a day to the eventual low of 90 million gallons a day by 2008.

In 1999, Tampa Bay Water approved plans to build a $110 million desalination plant at Apollo Beach that would churn out 25 million gallons of freshwater a day. Desalination boosters around the world were excited about the plant because of the apparent breakthrough in price it would achieve. Relatively low salinity in the bay, cheap energy, and sharing infrastructure with the Big Bend Power Plant all helped lower costs. The desalination plant would be privately owned and operated by a consortium including Poseidon Resources and Stone and Webster Company. The team committed to begin operating the plant in 2002, and to deliver desalinated water at an unprecedented wholesale cost of just under $2 per thousand gallons. At the time, large-scale seawater desalination cost between $4 and $6 under "optimum" operating conditions. It could cost as much as $10 per thousand gallons if the plant did not operate efficiently.[26] By comparison, it costs about $1 per thousand gallons to pump groundwater and deliver it wholesale.[27]

Looking back, Ken Herd, Tampa Bay Water director of operations, says his board never could have anticipated the bad luck that would dog the project. In 2000, Boston-based Stone and Webster, one of the world's largest and most respected engineering firms, declared bankruptcy. Its partner, Poseidon, then hired New Jersey–based energy giant Covanta to complete the plant. A year later, Covanta filed for bankruptcy after the energy crisis in California crippled its cash flow.[28]

Tampa Bay Water decided to take over ownership of the plant. It had access to cheaper financing than the private companies. Moreover, the most significant hurdle, environmental permitting, had been jumped.

The utility ousted Poseidon but stuck with Covanta after the bankruptcy so the company could finish the plant it started. A spin-off company called Covanta Tampa Construction completed the plant in the spring of 2003. On the day it produced its first 3 million gallons, Tampa Bay Water officials toasted with plastic cups. But the celebration was premature. When the plant began to produce near capacity, its expensive membranes started to clog. Covanta officials blamed invasive Asian green mussels that had been introduced into Tampa Bay in ship ballast water and grew on the intake pipes at the power plant, which provides the water to the desal plant. Tampa Bay Water officials believed the real culprit was Covanta's pretreatment system. Later that year, Covanta Tampa Construction went bankrupt before Tampa Bay Water could fire it.[29]

As this book went to press in 2006, the Tampa Bay Seawater Desalination Plant was still shuttered. Tampa Bay Water hired yet another impressive team of experts to get it up and running. American Water-Pridesa LLC is a joint venture between American Water Services and Pridesa S.A. of Spain. The team bid $29 million to fix the plant's pretreatment system, which the utility says is not rigorous enough to filter particles from seawater, causing the cartridge filters and desalting membranes to clog too quickly. Overall costs now have surpassed $148 million. The latest price estimates per thousand gallons of water, once an impressive $2, had climbed to $2.54. That was "still the lowest cost among operating desal plants of similar size throughout the world," according to Tampa Bay Water spokeswoman Michelle Robinson.

Herd and other Tampa Bay Water officials had faith that the plant would be up and running by 2007. If it is, the most interesting part of the story will still be this: over the years that the plant's troubles dragged on, the region managed to reduce its groundwater pumping from 192 million gallons a day to 121 million gallons a day despite population growth and *without* the desalted water the officials insisted they needed to meet that goal. Instead, a new, 15-billion-gallon reservoir and a 66-million-gallon surface-water treatment plant, combined with aggressive conservation initiatives, had slashed groundwater use in the region by more than a third without a drop of desalted water.

Herd says Tampa Bay just got lucky. Plenty of rain fell in the years the plant was shuttered. "The wisest thing we've done is diversify our water supply," he says. "The goal is to have a diverse, drought-resistant water portfolio, just like having a diverse investment portfolio. We will need desalination in times of drought."[30]

Still, it is a hugely expensive technology in places such as Florida that have not met efficiencies in water pricing or conservation. Even in oil-rich Saudi Arabia, Crown Prince Abdullah recently cited the high energy costs of desalting more than 570 million gallons of water a day when he urged residents to do a better job of conserving.[31]

Nature, itself, is a desalination plant of sorts. Heat from the sun evaporates water from the ocean's surface. The water vapor eventually comes into contact with cooler air, where it recondenses, then falls to earth as rain and dew. With its 1,400 miles of coastline and 55 inches of rainfall each year, Florida is a huge benefactor of this natural process. But even at that macro scale, desalination cannot slake the state's growing thirst.

Are desalination and other technologies really the best solutions? Or do they aggravate water-supply problems by enabling more and more people to squeeze into fragile places that do not have the water to support them? If desalination could save the 9,500 children who die each day because of lack of good water, it could well, in President Kennedy's words, "dwarf any other scientific accomplishments." If it serves only to wedge more people into Florida, California, and Texas—the three fastest-growing and heaviest-water-using states are also the three biggest players in desalination—its promise is not so noble.