With a Grain of Salt

Pressed to find the water it needs, California gives desalination another try.

By Lorelei Laird

SAN DIEGO, MORE THAN MOST PARTS OF SOUTHERN CALIFORNIA, WANTS TO KEEP ITS WATER local. ¶From about 1987 to 1992, California had a series of drought years that depleted its water reserves. Dry years are not unusual in Southern California, which is why much of the region relies on two sources of imported water: the Colorado River, which delineates the California-Arizona border, and the State Water Project, which exports water from Northern California. At the time, the San Diego County Water Authority got 95 percent of its water from those sources, serving a population of about 2.5 million. ¶But Northern California also had a record drought between 1987 and 1992. Without enough water to go around, the Metropolitan Water District, the water wholesaler for Southern California, drastically curtailed its deliveries. San Diego declined to ration water—unlike other Southern California agencies—but its water supply was cut in half. Ken Weinberg, now water resources director at the county water authority, recalls angry people lined up around the block to get in his agency's front door.

The drought ended after 1992, but the water authority—a state-created agency that sources water for 24 local water agencies in the county—decided to diversify. "I would characterize it as a seminal moment in the water authority's history, if not most of California," says Weinberg. "Coming out of that experience, it was really clear to us that we needed to not have all our eggs in one basket."

The authority now gets about 40 percent of its water locally and counts seven sources of water in its portfolio, including conservation and wastewater recycling. In partnership with private developer Poseidon Resources, it broke ground in late 2012 on its eighth—and possibly most ambitious—source: the largest seawater desalination plant in the Western Hemisphere. Located in the north San Diego County suburb of Carlsbad, the Carlsbad Desalination Project is intended as another part of the diversification and water independence process the authority has pursued over the past 20 years.

Scheduled to be completed in 2016, the plant will supply just seven percent of the authority's water by 2020—between 48,000 and 56,000 acre-feet per year, according to the contract with Poseidon—and the water won't be cheap.

By contract, the authority will buy water from the Carlsbad plant at $1,849 to $2,064 per acre-foot. (An acre-foot is roughly enough water for two families of four for a year—slightly under 326,000 gallons.) That's about twice what the authority pays for MWD and SWP water.

But Weinberg and his colleague at the authority, deputy general manager Sandy Kerl, cite two reasons to look beyond the price difference. One is that the price of imported water is expected to rise faster than the price of desalinated water. According to the authority's calculations, the water prices could equalize as early as 2024 or as late as 2041.

And this plant's water can't be taken away by outside forces, as the authority's supply was in the early 1990s.

"A lower price that's unavailable is not helpful," notes Kerl. "One of the things we're getting with this project is a seven percent, locally controlled supply not subject to the whims of Sacramento or D.C. or earthquakes."

San Diego County lies between the offshore Newport-Inglewood-Rose Canyon fault zone and the Elsinore fault zone in the mountains to the east. Part of the authority's

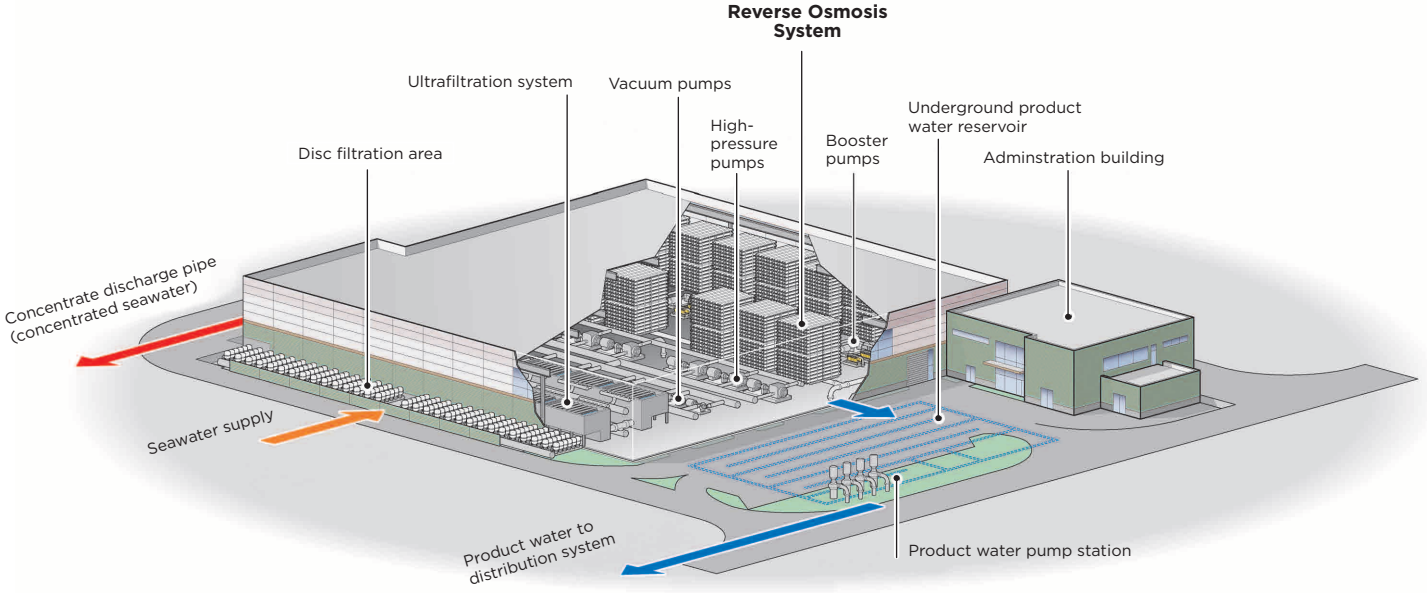
The Carlsbad Desalination Project

Site scheme by Poseidon Resources, www.poseidonwater.com

STEP 1 The Desalination Plant

Seawater from the Encina Power Plant cooling system (orange arrow) is pumped into the disc filtration system and ultrafiltration system. Then, through the use of high-pressure pumps, pressure exchange arrays, and booster pumps, the water is forced through the reverse osmosis system.

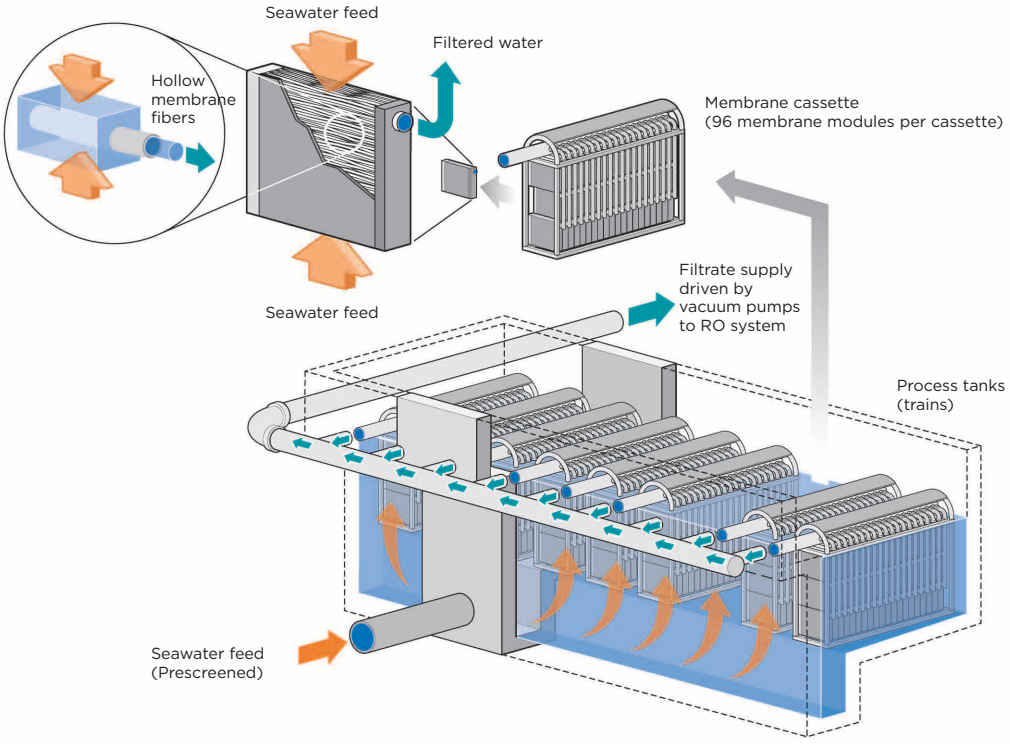
The ultrahigh-quality product water, also called permeate (blue arrow), is piped into the product water storage tank. From there chemicals (lime, carbon dioxide, and chlorine) are added to the product water to prepare it for delivery into the local and regional potable water distribution system.



STEP 2
The Ultrafiltration System

After the seawater passes through the disc filtration system it flows into the ultrafiltration process tanks, where remaining fine particles are removed. Thousands of hollow membrane fibers like long strands of angel hair pasta, are housed in membrane modules and immersed in the process tanks. These fibers draw seawater through their semi-permeable surface in an "outside-in" flow path. The pores of each membrane form a physical barrier to the impurities in the seawater. This process produces high-quality filtrate supply water for the reverse osmosis system.

The membrane modules, containing the thousands of hollow membrane fibers, are assembled into membrane cassettes of 98 modules each. Each process tank contains eight "on-line" membrane cassettes with one additional stand-by cassette.



DESALINATION BY THE NUMBERS

Source: International Desalination Association, 2011

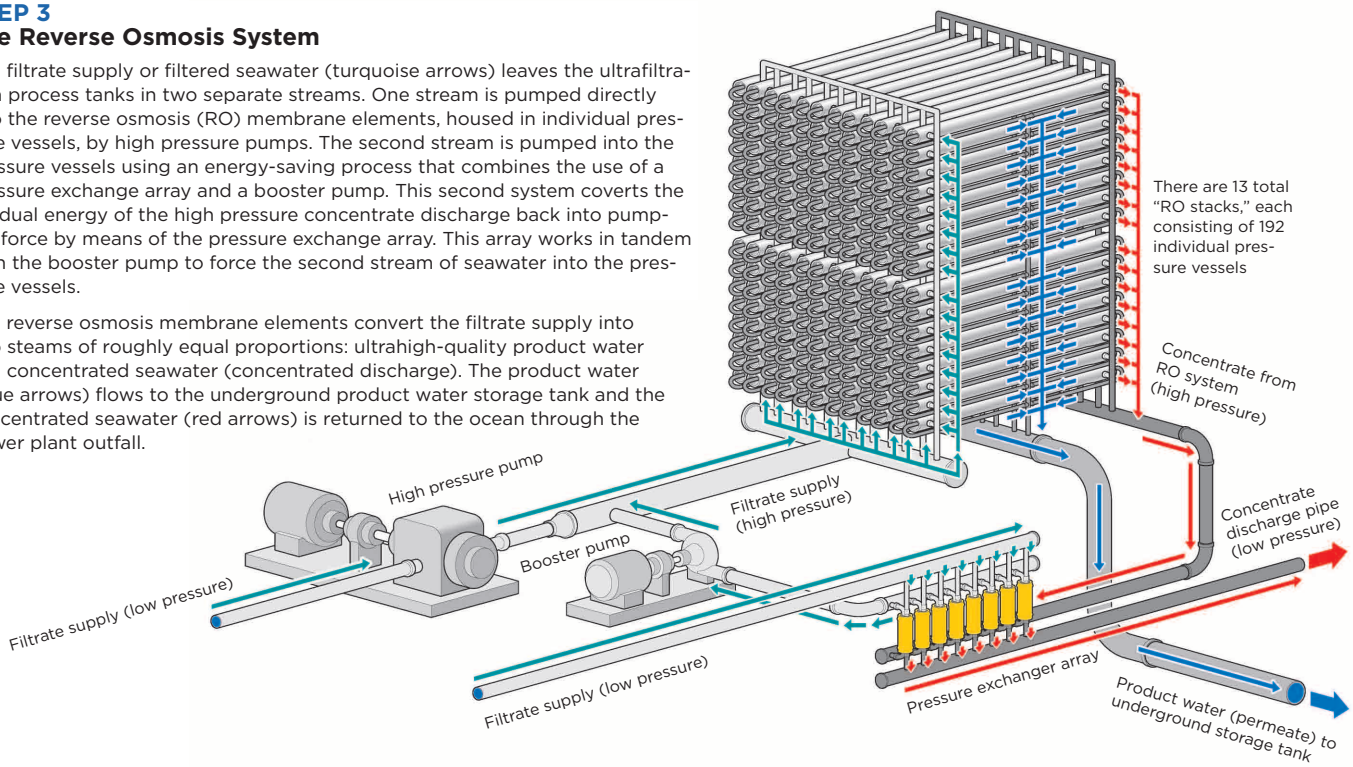
150 The number of countries where desalination is practiced

15,988 The number of desalination plants worldwide

STEP 3
The Reverse Osmosis System

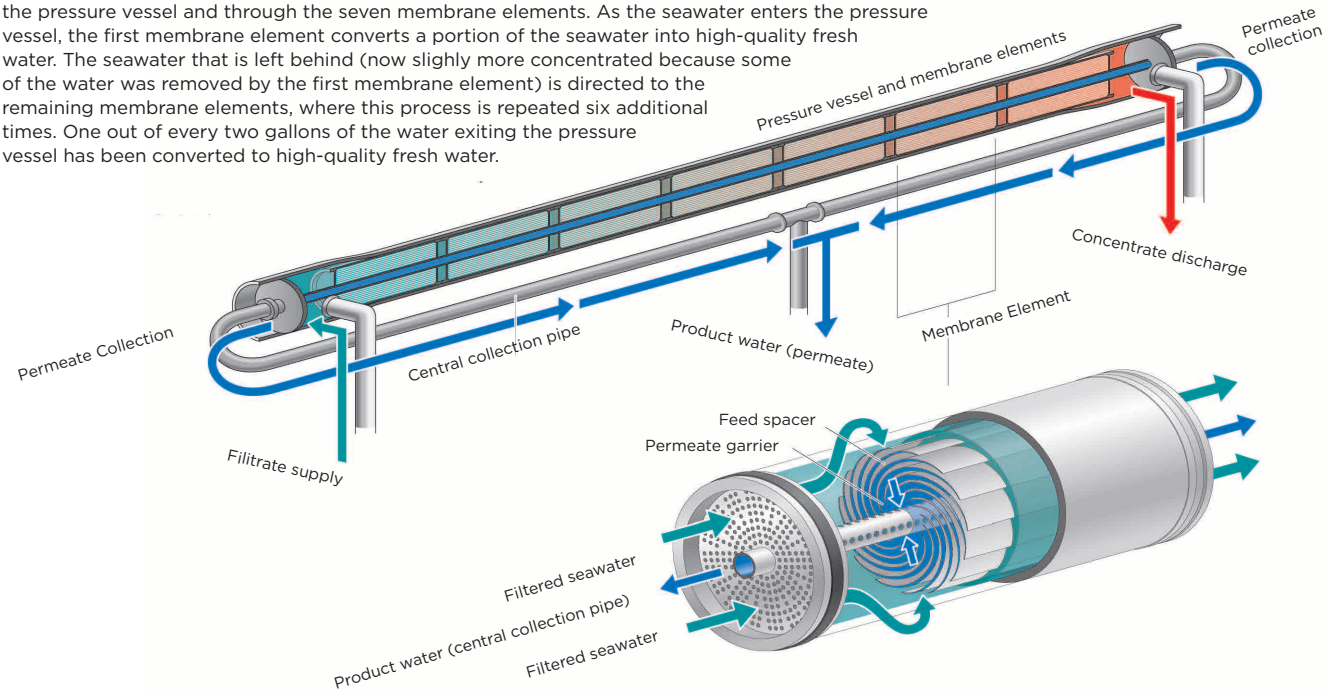
The filtrate supply or filtered seawater (turquoise arrows) leaves the ultrafiltration process tanks in two separate streams. One stream is pumped directly into the reverse osmosis (RO) membrane elements, housed in individual pressure vessels, by high pressure pumps. The second stream is pumped into the pressure vessels using an energy-saving process that combines the use of a pressure exchange array and a booster pump. This second system coverts the residual energy of the high pressure concentrate discharge back into pumping force by means of the pressure exchange array. This array works in tandem with the booster pump to force the second stream of seawater into the pressure vessels.

The reverse osmosis membrane elements convert the filtrate supply into two steams of roughly equal proportions: ultrahigh-quality product water and concentrated seawater (concentrated discharge). The product water (blue arrows) flows to the underground product water storage tank and the concentrated seawater (red arrows) is returned to the ocean through the power plant outfall.



STEP 4 The Reverse Osmosis (RO) Pressure Vessels

The conversion of seawater into high-quality fresh water takes place within the RO membrane pressure vessels. Each vessel contains seven replaceable membrane elements. The filtered seawater (turquoise arrows) is pumped into the membrane pressure vessels, under pressure. The seawater is forced along the length of the pressure vessel and through the seven membrane elements. As the seawater enters the pressure vessel, the first membrane element converts a portion of the seawater into high-quality fresh water. The seawater that is left behind (now slighly more concentrated because some of the water was removed by the first membrane element) is directed to the remaining membrane elements, where this process is repeated six additional times. One out of every two gallons of the water exiting the pressure vessel has been converted to high-quality fresh water.

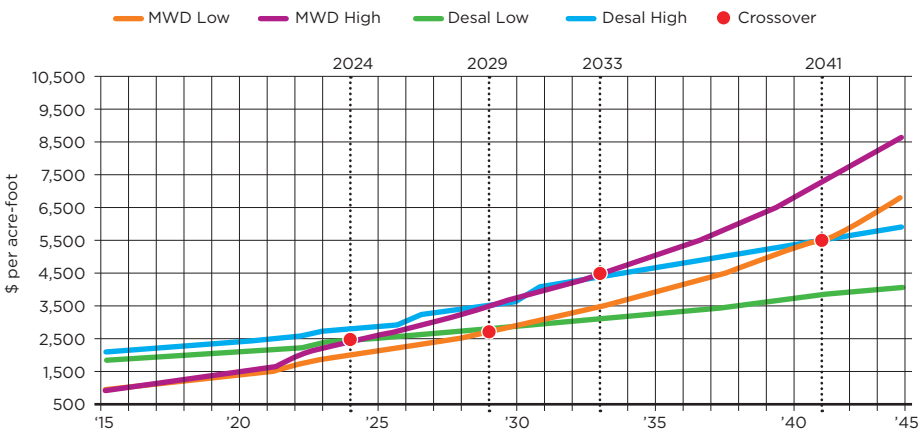


300 million The number of people around the world who rely on desalinated water for some or all their daily needs

17.5 billion U.S. gallons The equivalent of 66.5 million cubic meters per day

Comparing the Project Cost of Seawater Desalination and MWD Full-Service Treated Water

Based on assumptions that consider inflation, price caps, growth rates, and other factors.



Source: San Diego County Water Authority

contract with Poseidon requires it to comply with all building code requirements, including the seismic safety provisions of the California building code. The city of Carlsbad will review the plant's plan for compliance, and has already started reviewing plans for a related pipeline.

Better technology

The reverse osmosis technology this plant will use is not new, but reverse osmosis seawater desalination has not been widely adopted in the U.S. That's largely because it's not as cheap as conventional water sources. In fact, U.S. seawater desalination plants have been underused because of this factor. After the 1987–1992 drought, plants were built in several California cities—but after the drought ended, many were shut down or used intermittently. And in Florida, the Tampa Bay Seawater Desalination Plant is running below capacity because of the price difference.

Overseas, it's a different story. Reverse osmosis seawater desalination plants, many built in the last 15 years, exist in North Africa, Australia, South Asia, and the Middle East. The world's largest reverse osmosis seawater desalination plant, producing 103,000 acre-feet a year, is the third of five plants being built in Israel.

These more recent plants take advantage of advances in reverse osmosis membranes, which have gotten more efficient, cheaper to produce, and longer lasting over the past 20 years. That's according to Peter MacLaggan, senior vice president for project development at Poseidon, which has built one other desalination plant, the Tampa Bay facility. It's actively pursuing more plants in Florida, Texas, and Huntington Beach, California, and has built several wastewater treatment and reclamation plants in Mexico. MacLaggan says desalination plants are also less expensive now because they're larger and can take advantage of economies of scale.

That's one reason why San Diego County took another look at desalination. Another, MacLaggan says, is that traditional water supplies are no longer cheap and plentiful.

"It's the subject of intense competition," he says. "It's not just people, but fish, wetlands ecology, and endangered species issues in the State Water Project."

MacLaggan points to 2003, when an agreement between seven western states ended California's practice of taking more than its share of Colorado River water. As other states grew, they no longer had a surplus that California could use. The state lost the rights to use 500,000 to 600,000 acre-feet of water each year, which, MacLaggan says, "all came out of the hide of the Metropolitan Water District."

At the same time, he says, the SWP has reduced its water deliveries to urban areas over the past decade, stymied by Endangered Species Act regulations that required more water in the Sacramento–San Joaquin Delta in Northern California.

And at least officially, California's population is expected to rise. The state department of finance estimated this year that total population will hit nearly 52.7 million by 2060—39 percent higher than its 2012 Census population estimate. All those people would add pressure to urban water supplies, and to the farms that feed cities.

For all these reasons, Poseidon and the authority believe desalinated water won't be more expensive than conventional water forever.

Heather Cooley is a researcher at the Pacific Institute, an Oakland, California, institution that studies water and environmental issues. She says that while supply in California is indeed constrained, there's good news on the demand side. Thanks to conservation and shifts in the American economy, water use per capita has dropped in recent years. (See "The Water Demand Revolution" elsewhere in this issue.) Further, there's some evidence that the state's population won't grow as rapidly as the state department of finance projects.

Cooley and her colleagues calculate that desalinated water runs from $1,900 to $3,000 an acre-foot, making it generally more expensive than other water sources. However, she says, "a more reliable source of water is worth more." In San Diego, which still depends largely on imported water, that extra cost can be justified, she believes.

Risk balancing

Nevertheless, the water authority has taken steps to control those costs. In particular, says Kerl, project planners learned from the experience in Tampa Bay, where the plant opened five years late and $40 million over budget, plagued by construction problems after it took over from private developers (including Poseidon).

"One of the things we learned from that is that Tampa was a very hands-off process from the public agency," says Kerl. "What we have here is truly a public-private partnership where the authority hired its own experts to provide technical advice on every aspect of the process."

She adds, "You can see it in our water purchase agreement, which is 300 pages with another 500 to 600 pages of technical appendices."

Cost concerns drove the decision to build the Carlsbad Desalination Project as a public-private partnership, Kerl says. Poseidon raised the money and will build and own the plant; it also went through the permitting and environmental review process, which required six years and attracted litigation. Weinberg says this alone was a

large risk the authority was happy to avoid.

Nor will the authority and its customers pay the financial cost of any construction problems, which were the source of many headaches in Tampa Bay. And allowing someone else to build the plant reduced demands on the authority's finances, a concern for municipalities with budget constraints.

"[There's a] higher cost due to private equity, but . . . the water authority is not on the hook for cost overruns," Kerl says. "We felt that was an appropriate placement of risk."

In return for taking on that risk, Poseidon receives a guarantee that the authority will buy the water—no matter how cheap and abundant other sources may be.

Cooley says that while the authority may be insulated from construction risks, the obligation to buy so much water from the Carlsbad plant exposes it to "demand risk." That's the risk of being locked into the costs of desalination even though cheaper alternatives are available.

"The demand risk issue is the main reason that the Tampa Bay plant is not operating at full capacity," she notes. "With San Diego, they did what's called a take or pay contract, so they've committed to buying almost the entire amount. If there are cheaper alternatives available, they're not able to [take advantage]."

Love that dirty water?

Another concern about desalination plants—one that drives up the cost of development—is their environmental impact. When seawater is taken into a desalination plant, the marine life living in that water is killed. There are also concerns about the other end of the process, when very salty brine is discharged and could hurt organisms living on the ocean floor.

Indeed, the fiercest opposition to the Carlsbad plant came from two environmental groups: the San Diego chapter of the Surfrider Foundation and San Diego Coastkeeper, organizations dedicated to protecting the coast. They have unsuccessfully pursued nine lawsuits and five administrative appeals of permits related to the Carlsbad plant.

Joe Geever, water programs manager at the San Diego Surfrider Foundation, says his organization opposes desalination because there are cheaper and less environmentally harmful alternatives. Wastewater recycling and stormwater recapture would not only address water scarcity, he says, but they'd reduce pollution and conserve water as well.

"We would argue that those are the things they should do first," says Geever. "In our opinion, seawater desalination would be a last resort."

In addition to opposing the plant outright, the environmental groups also argued for design features that would reduce the deaths of organisms sucked in with seawater. While the Encina Power Station—the 1950s-era power plant that will be adjacent to the desalination plant—is still operating, the desalination plant will use its discharged cooling water. But Encina is likely to shut down in the next few years, and when that happens, Poseidon plans to simply take over its "open ocean intake" pipe.

Geever says he would have preferred one of two modern intake technologies that cost more but screen out most or all of the sea life. He points out that the state of California is considering whether to require them in desalination plants.

"We think those will probably require, if not sub-seafloor intakes, at a minimum these [cylindrical wedge] wire screens," he says. "Carlsbad may have to go back and completely redesign the facility to comply with these regulations that haven't been adopted yet."

Similarly, the Surfrider Foundation opposed Poseidon's plan to mitigate the brine discharge problem by diluting it with more seawater—"tripling the marine life mortality from the intake to avoid the threat of habitat degradation," Geever says. He says a discharge pipe that can prevent salt from settling was rejected.

Nonetheless, Geever says, "it's far from over." He believes the new regulations will be enacted in early 2014, which may require Poseidon to spend more money retrofitting than it would have if it had adopted the mitigation technologies.

Heather Cooley points to a third environmental problem with desalination plants: greenhouse gas emissions from the large amount of energy used to pressurize water for reverse osmosis. That typically means electricity from coal-fired power plants.

Poseidon agreed with the state to make Carlsbad net-carbon neutral (measured against State Water Project water). Some of the ways it's doing that include buying carbon offsets and green energy credits, putting solar panels on its roof, and replanting trees in a burn area east of San Diego. To mitigate the plant's effect on sea life, Poseidon is also required to restore up to 55.4 acres of wetlands in the San Diego Bay.

Uncharted waters

For-profit developers of desalination projects are betting there will be demand for their water as increased competition and energy costs drive up prices. Carlsbad is the biggest California plant in development and opening fairly soon, but the Pacific Institute counts 18 other proposals in California alone.

IDE, the Israeli contractor that will design and supply the Carlsbad plant—and has built multiple plants in Israel—sees Carlsbad as its entrance into the North American market. Poseidon is in the early stages of a second desalination plant in Orange County.

"I think everybody's waiting to see if we get this deal done," says Kerl. ■

Lorelei Laird is a Los Angeles freelance writer who specializes in law and policy. Her website is www.wordofthelaird.com.

RESOURCES

MORE

Carlsbad Desalination Project: http://carlsbaddesal.com.

San Diego County Water Authority: www.sdcwa.org/desalination.

The Pacific Institute's reports on desalination projects in California and key issues of the practice: www.pacinst.org. Tampa Bay Seawater Desalination Facility: www.tampabaywater.org/tampa-bay-seawater-desalination-plant.aspx.The Santa Barbara Charles Meyer Desalination Facility: www.santabarbaraca.gov/Government/Departments/PW/DesalSum.htm.

Desalination projects in Texas from the Texas Water Development Board: www.twdb.texas.gov/innovativewater/desal/index.asp.