



Aqueducture Singapore imports 40% of its water from Malaysia through a trio of pipes, top, that run along the causeway connecting the two nations.

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Singapore's All Wet

By Neel Chowdhury

In Singapore, there is water everywhere and, belying the old adage, almost every drop can be drunk. Much of Singapore's water falls from the sky. Stand outside in the afternoon, when dark thunderclouds usually roll by, and you will probably get drenched. An average of 7.9 ft. of rain falls on Singapore annually, nearly 2½ times the global average. Moreover, this small, chestnut-shaped, 268-sq.-mi. island is surrounded by water, albeit the salty kind.

Hot, equatorial, but with limited groundwater, Singapore has made itself a global paragon of water conservation by harvesting--and reusing--the aqueous bounty of its skies and, to a lesser extent, its surrounding seas. "It is an exemplary model of integrated water management," said Lars Gunnarsson of the Stockholm International Water Institute in the citation given to Singapore's national water agency when it won the 2007 Stockholm Water Industry Award. "The story would fit well as a study example in the education of water managers."

Water is chronically in short supply in the world's megacities. In the arid Western U.S., cities like Los Angeles and Phoenix are in constant legal scrapes over access to the stuff, and

there are strict rules for homeowners about usage. By 2025, 1 in 2 Africans could face water scarcity, leading to potential water wars between countries. Chronic shortages are also expected in Asia. And groundwater supplies in three of India's most productive agrarian states are rapidly shrinking.

Singapore's success story, like many happy ones, began in struggle. "When you have your back against the wall, you come out fighting," says Sam Ong, deputy CEO of Hyflux, a Singapore-based water-treatment company. "That's how Singapore is with water." The fight dates back to several old water agreements with Malaysia, the country Singapore acrimoniously broke away from in 1965--which ensured that as of Singapore's independence, 80% of its freshwater supply came from Malaysia through fat steel pipes across a causeway. Yet soon after Singapore signed the agreements over the course of 1961 and 1962, it began formulating Plan B. Fearing that its erstwhile master would use water as a "lever of pressure," as Singapore's first Prime Minister, Lee Kuan Yew, put it in his memoirs, the country has searched for more than 40 years for ways to wean itself off foreign water.

It has succeeded. Even though roughly 40% of the country's freshwater still comes from Malaysia, by building a sophisticated network of rivulets, storm drains and canals, Singapore has made itself into a vast catchment area for the thundershowers that regularly soak it. "We are a large-scale urban storm harvester" is how Khoo Teng Chye, chief executive of Singapore's PUB (formerly known as Public Utilities Board), puts it. "We do not have any groundwater, but we do get a lot of rain," Khoo says. "That was the starting point of our efforts."

And Singapore purifies and recycles what it captures, including sewage. Here's how it works: More than half the island is crisscrossed by a grid of drains that not only prevent flooding, to which low-lying Singapore is prone, but more important, capture rainwater. That rainwater eventually flows into canals. From the canals, the water runs to one of several reservoirs and then to a treatment plant, where it is purified for home use. The wastewater, meanwhile, runs into a gigantic underground pipe, nearly as wide as a subway tunnel, that traverses the length of Singapore. To speed the water flow, this giant pipe tilts progressively downward, reaching a depth of 230 ft. By that point, hundreds of millions of gallons of water have arrived below a lip of reclaimed land on the easternmost edge of Singapore. There, a newly opened \$2.5 billion water plant pumps the water back to the surface and treats it, discharging some of it out to sea and treating some of it further for use

in factories. Not only are rainwater and wastewater efficiently "harvested" in this way, officials point out, but the system also makes every Singaporean water-conscious. "We want to promote the idea that the water that falls on your roof, patio or car park is eventually used," says the PUB's Khoo. "This ensures the environment is kept clean."

The government's enlightened policies have developed an expertise in water management that has spawned a host of profitable companies. Chief among them is Hyflux, a water-treatment company that purifies waste-, salt- and rainwater. Hyflux was started in 1989 by a chemistry graduate named Olivia Lum, who grew up so poor in a Malaysian village that rains regularly flooded her grandmother's small wooden house.

The company struggled for nearly half a decade. Then came the penguins. "To convince Singapore [that it could treat water], we tried our first project in a bird park with the penguin tank," explains Hyflux's Ong. Because penguins are used to pristine arctic water, the water in their tank needed to be continuously cleaned. The penguins were pleased enough by Hyflux that the company was allowed to recycle part of Singapore's wastewater into drinking water, which has in turn propelled Hyflux from a start-up into a global player in water treatment. Its systems are now used in cities such as Tianjin, China, and Magtaa, Algeria.

Hyflux's membrane technology shows that even the dirtiest water can be cleaned. Seawater in Singapore, for instance, is first dosed with acids to adjust alkaline levels and then cleaned of contaminants like oil and grease. The water passes through a sieve of sand that removes silt. Then it is shot through a stringy honeycomb of plastic membranes at high pressure, which "polishes" the water, Ong says. In the case of desalination in Singapore, Ong adds, the water becomes so clean that minerals have to be restored for it to be consumed. In 2008, Hyflux reported net profits of \$40 million, a 79% increase over the previous year, on revenues of roughly \$382 million. Hyflux's stock has jumped almost twentyfold since its public listing in 2001.

Not all of Singapore's water babies harbor such commercial promise. To highlight its prowess at converting wastewater into drinking water, the government created a drink called NEWater and packaged it in colorful plastic bottles. Although it's copiously drunk by Singaporean government ministers, often at media-saturated events like the country's National Day celebrations, brands like Evian and Perrier have little to fear. Singapore's

officials are more interested in making a point than a dollar, the point being that water is a valuable, renewable resource.

The country's painstaking efforts to become self-sufficient in water have worked. The first of the water agreements with Malaysia, which expires in 2011, is not likely to be renewed, according to a book sponsored by the Singapore government. Equally important, by using so much of its land to capture rainwater, Singapore has made its citizens environmental stewards who take responsibility for conserving resources. "It's a passion," says Albert Phee, a 49-year-old IT expert who has persuaded his family to turn off the shower while shampooing and reuse the water he washes his car with for flushing the toilet. "Once I've started, I can't stop."