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Peak Water? The Limits of a Resource

When you turn on the faucet at your kitchen sink what do you expect to happen? You expect to get an unlimited supply of fresh potable water to use as you choose in your daily activities such as cooking, cleaning, drinking, flushing, and watering. In most of the developed world, this availability is hardly considered. But just where does that water come from and is it really unlimited or is the earth headed for a crisis?

Water is the ultimate renewable resource. It falls from the sky and a vast reservoir covers 70 percent of the globe. There is no less water today than there was 100 years ago, 1000 years ago, or even a million years ago. Water cycles through the biosphere in a matter of months or years. Surely there is no shortage of water. Yet, each week the media reports on another region in the United States or the world where insufficient water is causing economic hardships, human and ecological suffering, or conflict.

It turns out, that for a large part of the world, there is a shortage of usable, fresh, clean water. Whether due to climate change, poor resource management, over population, reckless use, or willful neglect, more than one billion people do not have access to an adequate supply of potable water and more than 2.5 billion do not have water for basic sanitary needs. Does this scarcity mark the limit of the resource? If water is the new oil, have we reached "Peak Water?"

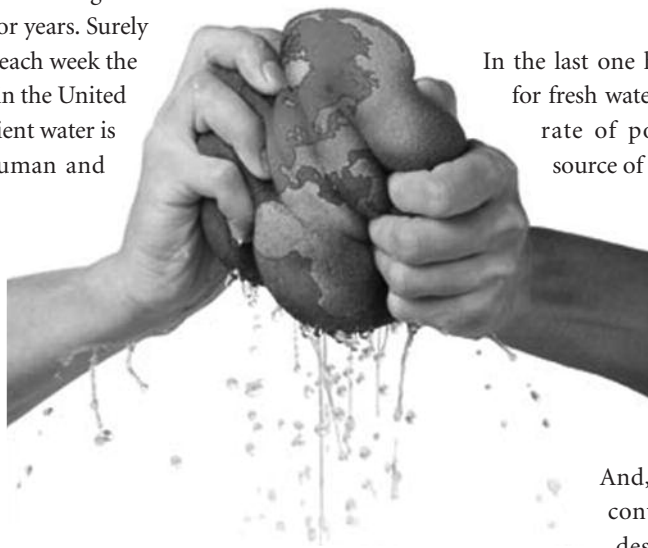
Reaching the Limits

Approximately 97.5 percent of all the water on Earth is salty or polluted and unsuitable for human use. Of the remaining 2.5 percent, nearly 70 percent is frozen in the ice caps of Greenland

*We never know the worth
of water till the well is dry.*

Thomas Fuller,
Gnomologia, 1732

and Antarctica. Large amounts of the unfrozen fresh water are found in soil moisture, trapped in deep water-bearing formations, or present as atmospheric water vapor. Only about one percent of the world's fresh water, less than 0.01 percent of all of the world's water, is available for direct human use in lakes, rivers, reservoirs, and easily accessible aquifers. Like oil, water is not equitably distributed, respectful of political boundaries, or found in abundance where the demand is greatest. Just as some nations have great oil resources and others do not, so it is with water. About 50 percent of the world's fresh water lies in just a half-dozen lucky countries led by Russia and Brazil. This has created a fierce competition for this fluid treasure.



In the last one hundred years, worldwide demand for fresh water has increased six-fold – twice the rate of population growth. The ultimate source of all available fresh water is precipitation that falls on the continents.

This amount is estimated to be approximately 40,000 to 50,000 cubic kilometers per year. And with annual population increases of about 85 million per year, the availability of fresh water per person is diminishing rapidly.

And, this assumes that the amount of continental rainfall remains constant despite evidence that climatic shifts

may be altering long-term precipitation patterns.

Agricultural uses put tremendous stress on available fresh water resources. Approximately 70 percent of all fresh water is used for agricultural purposes worldwide. Dry Pakistan uses 97 percent of its fresh water for agriculture, and China, with 20 percent of the world's population but only 7 percent of its water, uses 87 percent of its fresh water to irrigate crops. **From the Editor** continued on page 9

Globally, many regions are facing water crises. A few of these are: **Australia.** Australia is the most arid continent after Antarctica. Even with a population less than one-tenth of the United States, water resources are stretched to the breaking point. The worst drought in history is ravaging the nation. Rainfall has declined to 25 percent of the long-term average and is projected to plummet another 40 percent by 2050. Every major city in Australia has severe water restrictions in place and agriculture is crippled. In 2008, huge unchecked wildfires swept across the desiccated landscape.



This is a western grey kangaroo, photographed in 2002, halfway through Australia's worst drought in 120 years. Over 90 percent of the kangaroos on Yathong Nature Reserve died during the dry spell. Source: University of California Berkeley, College of Natural Resources.

Middle East. A 2008 report by the World Bank estimates that the amount of water available per person in this arid and politically volatile region will halve by 2050.

Africa. Desertification has allowed the Sahara to claim large stretches of the surrounding countries. Lake Chad, one of the largest lakes in the world when first surveyed in 1823, has shrunk from a surface area of approximately 10,000 square miles in 1960 to less than 600 square miles by 2000. "Africa is one of the most water-impooverished regions...and the lack of clean water claims the lives of 4,900 children every day," United States House Foreign Affairs Subcommittee on Africa Chairman Donald Payne said in 2007.

China. The Yellow River, China's second longest, supplies water to over 150 million people and irrigates 15 percent of the country's farmland. But in recent years, water levels in the upper reaches of the river have hit historic lows and it has occasionally run dry before reaching the sea. Probe International, a leading development policy group, has warned that the city of Beijing faces economic collapse and will need to resettle part of its population in coming decades, as it could run out of water in five to 10 years. China is in the process of building the multi-billion dollar North-South Water Diversion Project to bring water from the nation's longest river, the Yangtze, to the parched north.

Conflict

A study showed that 85 percent of the world's population resides in the drier half of the Earth where the limited resource is stretched thin. Many people in these regions are forced to turn to polluted water for their daily needs. Unsafe water is the primary cause of mortality around the world and kills ten times as many people as wars. Every year, eight million people, including 1.8 million children, die of the water-borne diseases diarrhea, cholera, typhoid and malaria.

*Water, water, every where,
And all the boards did shrink;
Water, water, every where,
Nor any drop to drink.*

- Samuel Coleridge (1772-1834).
The Rime of the Ancient Mariner, II

Water woes could have an impact on global peace and stability. In January 2007, United Nations Secretary-General Ban Ki Moon cited a report by International Alert, a self-described peace-building organization based in London. The report identified 46 countries with a combined population of 2.7 billion people where contention over water has created "a high risk of violent conflict" by 2025.

The developing world is dividing into those who have sufficient water and those that want more. Stronger nations and rising economic powers such as China and India, coveting the weaker neighbor's water resources, may resort to unfriendly means to gain control of this wealth. China's looming water crisis has them eyeing the abundant resources in Tibet. The London Times reported in 2006 that China is proceeding with plans for nearly 200 miles of canals to divert water from the Himalayan plateau to China's thirsty central regions. Himalayan water is a particularly sensitive issue because that source supplies the headwaters to rivers that bring water to more than half a dozen Asian countries. Any plans to divert Himalayan water will likely cause great concern among Southeast Asian nations.

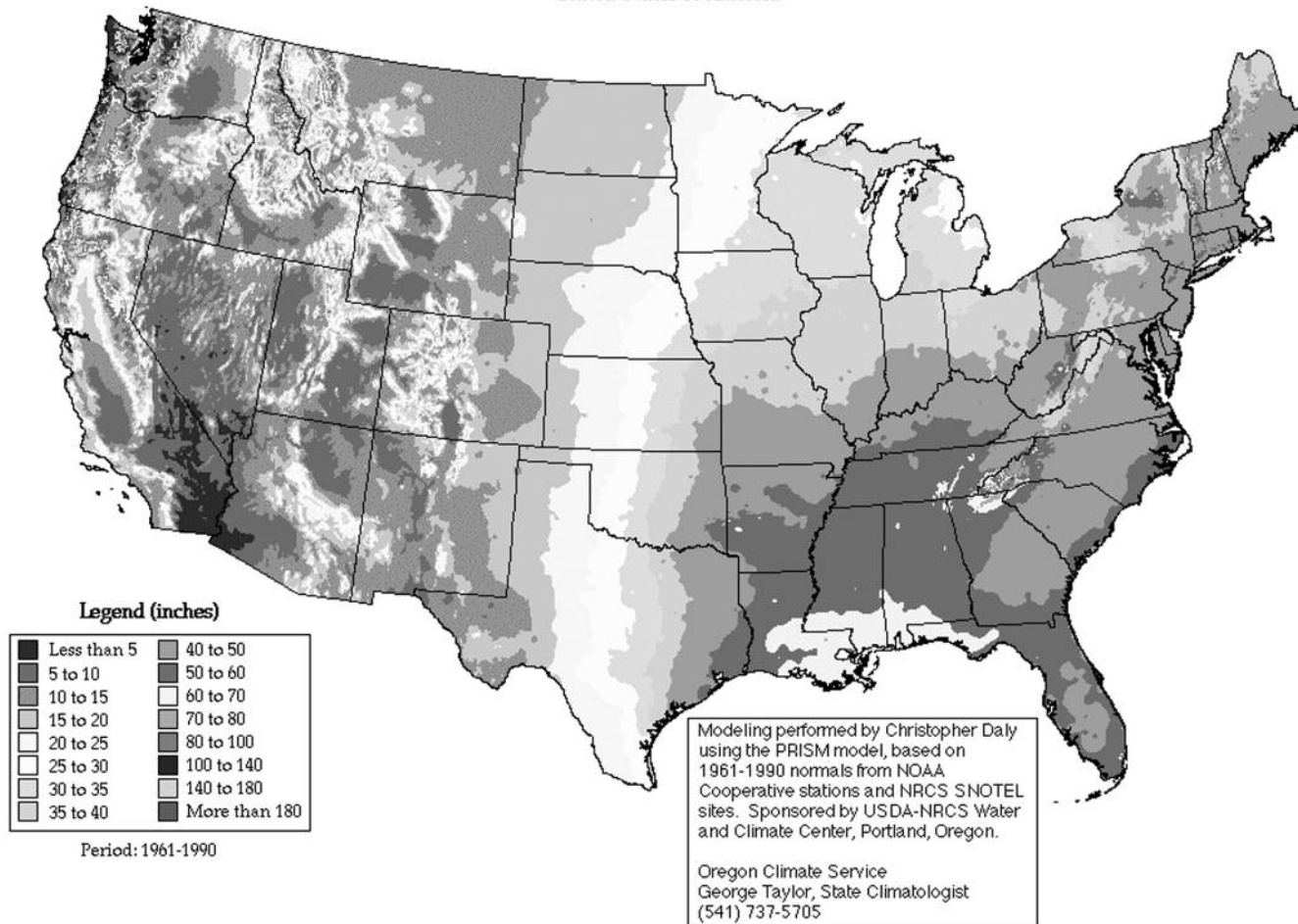
Canada, which has immense fresh-water resources equaling approximately 20 percent of the world total, is wary of its water-thirsty neighbor to the south. Water raises national fervor in Canada, and Canadians are reluctant to share their birthright with a United States that they perceive as profligate and with a long history of mismanagement of their own supplies.

*If the wars of this century
were fought over oil, the wars
of the next century will be
fought over water.*

- Ismail Serageldin, VP
World Bank, 1995

Annual Average Precipitation

United States of America



The prospect of losing control of its water under free-trade or other agreements is something Canadians seem to worry about constantly. In 2007, Canada's House of Commons voted 134 to 108 in favor of a motion to recommend that its federal government "begin talks with its American and Mexican counterparts to exclude water from the scope of NAFTA."

Even Texas has clashed with its neighbors, Mexico and Oklahoma, over access to water. The roots of the Texas-Mexican water dispute go back to the 1944 water treaty which determined how flows from several river systems would be divided. Mexico violated the treaty from 1993 to 2002 by withholding the agreed upon water contributions to the Rio Grande. Texan farmers, ranchers, and irrigation district officials sued the Mexican government for \$500 million in damages. Mexico finally made up its water debt in 2005. But many Texan farmers worry about the future as drought lingers throughout the region. In 2007, the Tarrant Region Water District, in the Dallas area, filed suit in the U.S. District Court for the Western District of Oklahoma naming the Oklahoma Water Resources Board and the Oklahoma Water Conservation Storage Commission. The Texas

water district argued that a moratorium passed by the Oklahoma Legislature to bar the exportation of water to other states violated the federal commerce clause. The lawsuit seeks a restraining order to prevent Oklahoma from using the moratorium to block the sale of water to Texas. The suit argues that Oklahoma has allocated only 7.6 percent of the 34 million acre-feet of water that flows out of the state each year into the Red River and Arkansas River. One acre-foot, the volume of water that can cover an acre to a depth of one foot, is approximately 326,000 gallons.

The United States and Texas

The United States is divided approximately in half along the line of 95 degrees west longitude, where the eastern half generally has sufficient precipitation to meet current water demands. West of this line, precipitation is sparse and in many areas, insufficient to meet current demands. The shortfall in these areas is made up with groundwater withdrawals for agricultural and municipal uses.

The American West, like much of the world, is incurring a vast

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and growing water deficit that is hidden by the lush green golf courses carved into the desert scenery. To bridge the gap between demand and the over-allocated surface water supply, non-renewable groundwater aquifers are exploited. Since World War II, there has been a gold-rush type explosion of water extraction to support the agricultural 'Green Revolution' and thirsty cities.

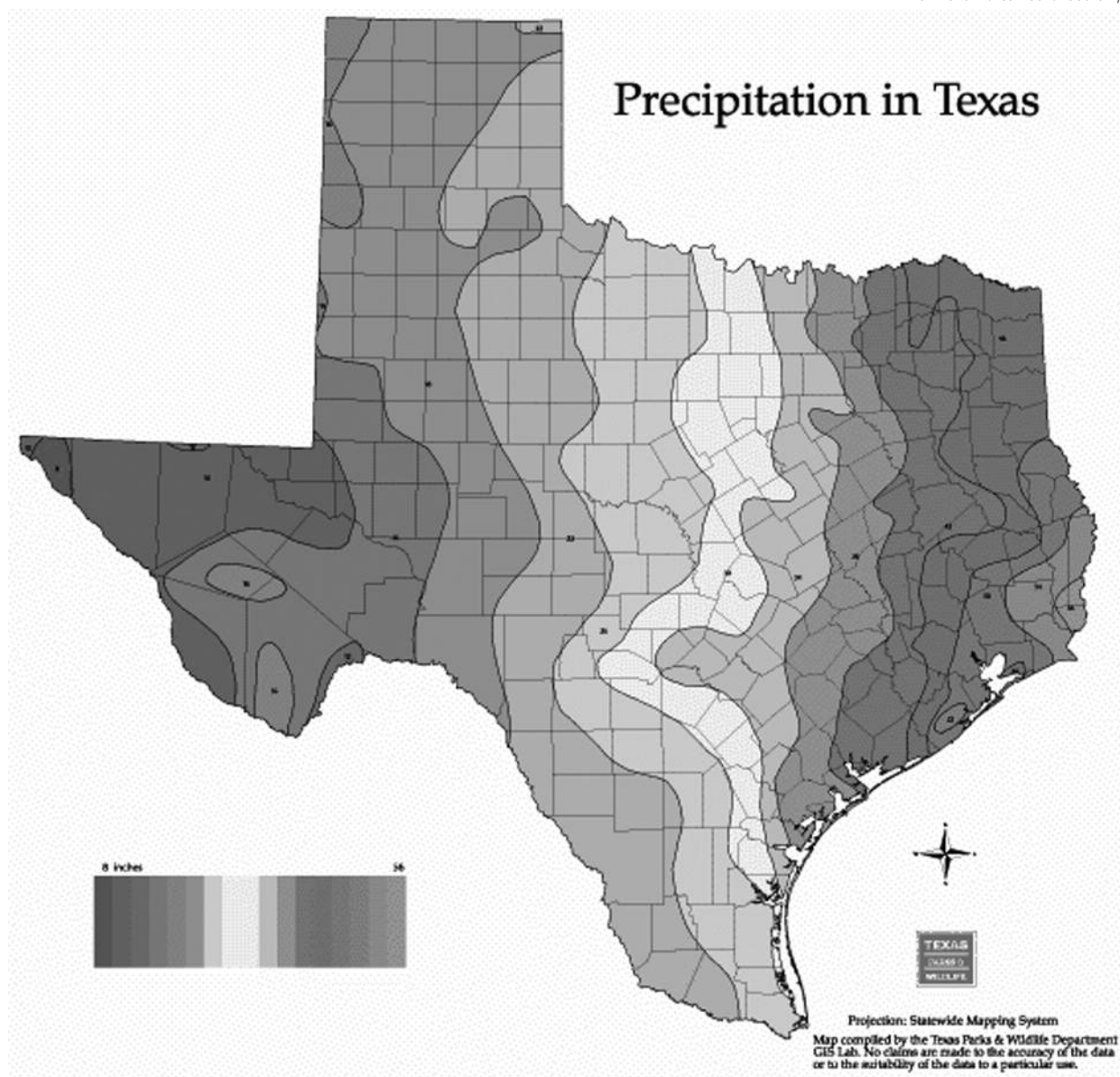
Despite the warnings to Congress in 1888 by explorer and geologist John Wesley Powell that the lack of water was a serious obstacle to unbridled settlement of the West, large metropolises such as Las Vegas, Phoenix, and even Los Angeles have spread across the arid lands where rainfall is often less than ten inches per year. Only by political clout and the expenditure of billions of dollars on vast public works projects, transporting water across hundreds of miles blistering desert, are these cities able to exist. Children are

taught that water flows down hill, but in the American West, as the saying goes, water flows uphill towards money.

La Vegas means "the meadows" in Spanish and was once a desert oasis with fresh water springs nourishing verdant grasses. Settlers on the journey west in the late 1800s stopped here to rest and water their livestock. The springs no longer flow and natural meadows are no longer found in Las Vegas due to the heavy draw on groundwater in southern Nevada to slake the thirst of the burgeoning population of Clark County. A new type of unnatural meadow, the irrigated lawn, is found throughout the region.

The Colorado River, the lifeblood of Southwest, is in serious trouble and no longer flows to the sea in most years. Seven states and dozens of Indian reservations, as well as Mexico, tap its flow.

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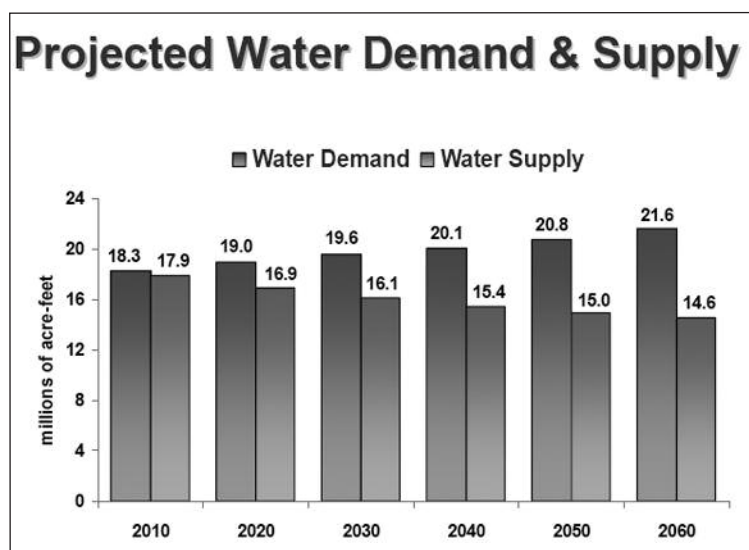
Average precipitation distribution in Texas in inches per year. Source: Texas Parks and Wildlife Department.

Development has sapped the river, a problem exacerbated by a drought called “perhaps the worst in 500 years” by United States interior secretary Gale Norton. Lake Mead, an immense reservoir that dams the Colorado to supply most of Phoenix’s water, has a 50-50 chance of running dry by 2021, according to a study by the Scripps Institution of Oceanography.

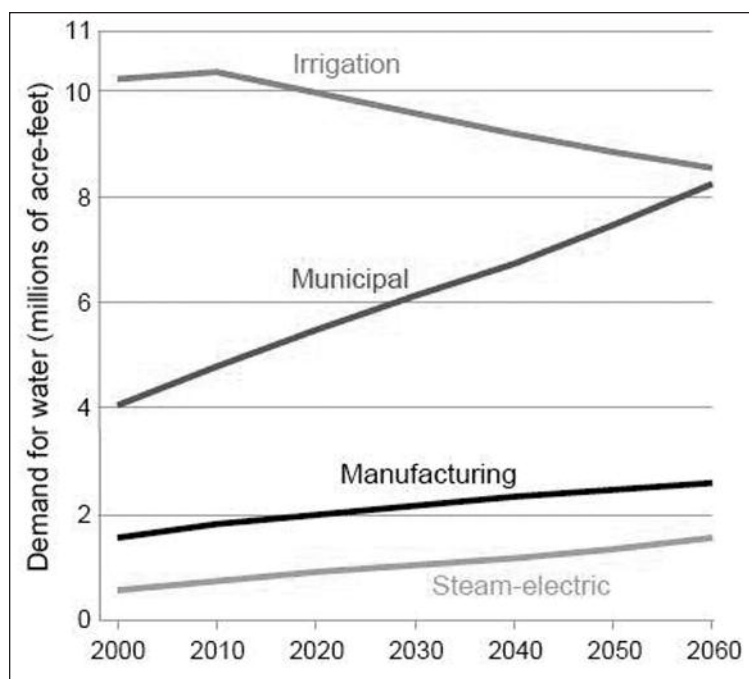
Texas’ situation mirrors that of the world and the Southwest. Its population is expected to nearly double by mid-century, from

20.8 million in 2000 to 39.6 million in 2050. Urban and rural centers have begun to clash over the allocation of water resources; in fact the growing municipal demand for water will be one of the greatest challenges facing Texas. The future living standard for Texans, particularly those in the arid western parts of the state, will depend largely on the availability and affordability of water.

Texas lies at a crossroad of water resources in the United States with precipitation rates ranging from more than 55 inches annually in



Projected water demand and supply in Texas 2010 to 2060. Source: Texas Water Development Board



Projected water demand in Texas for irrigation, municipal, manufacturing, and steam-electric uses. Source: Texas Water Development Board

the Beaumont area to less than ten inches annually in El Paso. Texas water resources are sufficient to meet current demand of approximately 17 million acre-feet per year. However, growing water supply demands largely due to population growth and declining supply due to climate shifts may soon lead to deficits. The Texas Water Development Board (TWDB) forecasts that agricultural water usage will decrease over the next 50 years, but that this decrease will be offset by huge increases in municipal usage. The TWDB projects that overall water demand in Texas will outstrip supply by 2010 with the deficit increasing to seven million acre-feet per year by 2060.

Houston water sources

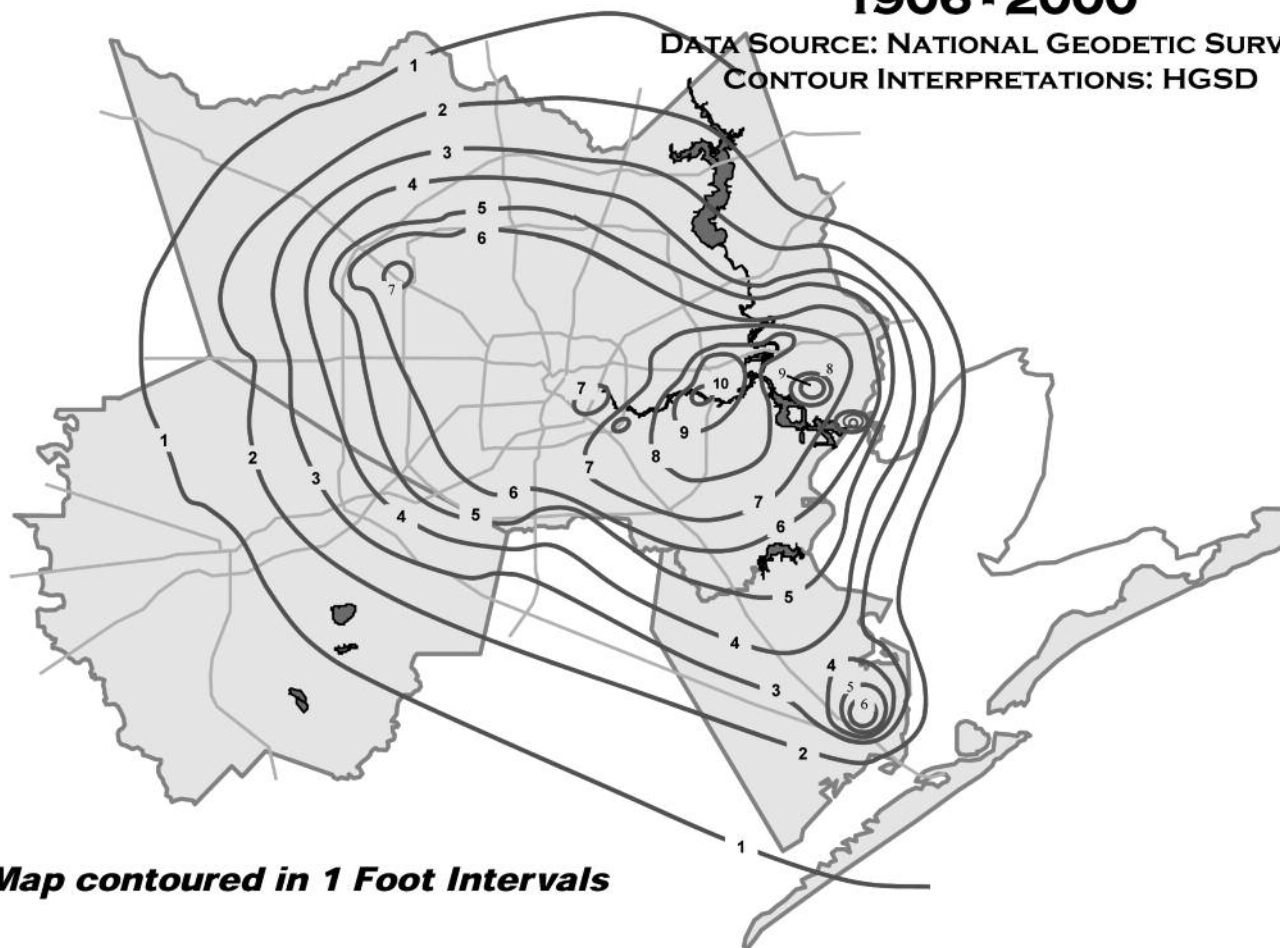
In Houston, our water supply comes from both surface water and groundwater sources. Houston was fortunate to be founded in a location that overlies the Gulf Coast aquifer, and wedge of prolific water-bearing sediments more than 1000 feet thick in Harris County. Growth in Houston and the surrounding areas was greatly aided by the plentiful water drawn from the Gulf Coast aquifer. However, these large groundwater withdrawals came at a cost. Depressurization of the aquifer led to subsidence of the land surface. This subsidence was greatest in the areas east of Houston near the ship channel where ground elevations declined by more than ten feet. Several neighborhoods had to be abandoned due to the flooding that resulted from the subsidence.

In 1975, the Texas Legislature created the Harris-Galveston Subsidence District (HGSD), the first of its kind in the United States. Authorized as a regulatory agency and created to end subsidence, the district is armed with the power to restrict groundwater withdrawals. The district has developed and implemented a plan to shift the municipal water source from groundwater to surface water. As groundwater use has declined, water withdrawals from the Trinity River have increased to the point where it makes up more than 50 percent of the 900 million gallon per day demand.

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SUBSIDENCE 1906 - 2000

DATA SOURCE: NATIONAL GEODETIC SURVEY
CONTOUR INTERPRETATIONS: HGSD



Map contoured in 1 Foot Intervals

Source: Harris-Galveston Subsidence District (www.hgsubsidence.org)



Summary

Wise management and sustainable develop of the world's water resources is a task that has been postponed too long. Much of the world is in crisis and parts of the United States are rapidly approaching that point. Water-poor regions can no longer expect to put off addressing the problem by pumping ever greater amounts of relict groundwater from shrinking aquifers. Geoscientists should play a leading role in designing innovative solutions such as aquifer storage and recovery (ASR) where seasonally-surplus water supplies are banked in porous underground formations for later use.

So, the next time you open the faucet in your home and draw a glass of clean potable water, take a moment to consider the precious resource that you hold in your hand. Before you raise the water to your lips, think about how many times it has recycled through the atmosphere, earth, and ocean. And most importantly, reflect on how fortunate you are to have all you want. ■