Water and Wastewater Infrastructure

Section 15

This section discusses water and wastewater (sewer) infrastructure issues. The two systems are increasingly integrated through dual distribution systems, which transport recycled water from treatment plants to farm or industrial users — thereby reducing the net amount of water needed. California is the leader in the use of reclaimed water for non-drinking purposes. As water shortages proliferate, we expect integration of the two systems will expand nationally.

If current trends continue, the population of the U.S. will rise from today's 300 million to almost 438 million by mid century. More than 80 percent of this growth will be due to immigrants arriving from 2005 to 2050 and their U.S.-born descendants. Liberal immigration legislation could boost that number even higher.[1]

Will population growth of this magnitude erode living standards for the average American? This question is often framed in terms of the future supply — and prices — of basic commodities like oil and food. But the real limiting factor may be water.

Water and Sewer Systems by the Numbers

850 billion gallons of untreated wastewater discharged annually
32 years average useful life of water treatment equipment
$390 billion to replace and build new wastewater systems over next 20 years.
$10,000 per household cost of replacing water mains and treatment plants
3 percent of U.S. electricity demand accounted for by water systems.

Water and Sewer Infrastructure Spending (a)
2005: $90.1 bil. ($305 per capita)

2050 projections (b):
$133.5 billion: at current population trends
$115.7 billion: at 50-percent reduction in immigration
$90.1 billion: at zero population growth

Notes:
a. Capital, operations, and maintenance spending by federal, state, and local governments in 2006 dollars.
b. Assumes per-capita spending remains at 2005 levels.

Sources:
Congressional Budget Office, American Society of Civil Engineers, American Water Works Association, Pew Research Center.

Water shortages, which used to be a problem in western states, are now a problem throughout the country. For example:

Florida: The state has hundreds of lakes and wetlands and receives more than 50 inches of rainfall a year. Yet it will run out of water unless its population growth slows or new water sources are discovered. The water shortage is so severe in parts of the state that people have been ordered to appear in court for violating water rationing standards.

Kansas: Parts of the High Plains aquifer will be used up within the next 25 years, and vast areas of land will have no usable groundwater in the next 50 years, according to the Kansas Geological Survey.

Idaho: Population growth is expected to nearly double the region's water demand by 2025. The major water supplier to Boise says it will have trouble supplying water to the city within two years.

Chicago: The metropolitan area is expected to suffer water shortages by 2020, by which time the region will have added about 1.3 million residents.

Even regions that once seemed to have unlimited supplies are losing the water war. In the suburbs around waterlogged Seattle, for example, the demand for water is outstripping supply, raising the prospect of shortages within 15 to 20 years.[2]

Water Infrastructure

By global standards, the U.S. is water rich. It has 4 percent of world's population but 8 percent of its fresh water.[3] But at approximately 1,500 gallons per person per day, Americans also consume more water than any other people on earth. The availability of fresh water varies widely by region and several trends—shifting population growth, aging water infrastructure, and global warming—make it increasingly difficult for many communities to meet demands placed on their water systems.

The provision of drinking water requires a massive complex of piping, pumps, and water purification works. Much of this infrastructure is aging and will reach the end of its useful life within the next 20 years or so. Maintenance costs are staggering.

The American Society of Civil Engineers (ASCE) estimates an annual need of $11 billion to replace aging water system facilities and comply with safe drinking water regulations. The corresponding national wastewater requirement is estimated by EPA to be $20 billion per year.[4] Annual federal appropriations for drinking water are envisioned at approximately $842 million through 2018, according to the Environmental Protection Agency's (EPA) Drinking Water Fund drinking water. Yet the Bush administration's FY 2008 budget sets annual spending for both water and wastewater infrastructure at less than one-tenth of the amounts deemed necessary.[5]

These amounts do not reflect the private water infrastructure needs. More than 1.7 million people in the United States—more than 670,000 households—still lack full indoor plumbing, the "basic plumbing facilities that most of us have come to take for granted," according to an April 2004 report.[6] Homes without adequate plumbing are concentrated among the poorest Americans in 10 states—California, New York, Texas, Florida, Pennsylvania, Illinois, Arizona, Virginia, Ohio, and North Carolina—but can also be found in Alaska (which, at 6.32 percent, has the largest fraction of all households) to Nebraska (which has the least, at 0.36 percent.)

In theory, the public water infrastructure shortfall could be closed if municipal water authorities raised the cost of water to consumers. This would allocate the costs of new infrastructure to the beneficiaries of that infrastructure—an economically efficient outcome. But for most large systems, this would require rate increases that would charge each household an additional amount ranging from $550 to $2,300 over the next three decades; smaller systems would impose even higher bills, ranging from $1,490 to $6,200 per household over a 20-year period.[7]

The conventional wisdom is that rate hikes of this magnitude are non-starters politically. Water consumption in the U.S. is the highest in the world—in large part because our water rates are the lowest in developed world. We like it that way.

Reality check: Americans buy billions of gallons of bottled water each year—at a per unit cost up to 10,000-times greater than tap water. Bottled water is also more energy intensive. Each year the bottles themselves require 17 million barrels of oil to manufacture, and the energy required for a bottle's production, transport, and disposal is equivalent, on average, to filling it one-quarter full with oil.[8]

As for quality, 40 percent of bottled water should be labeled bottled tap water, because that is exactly what it is.[9]

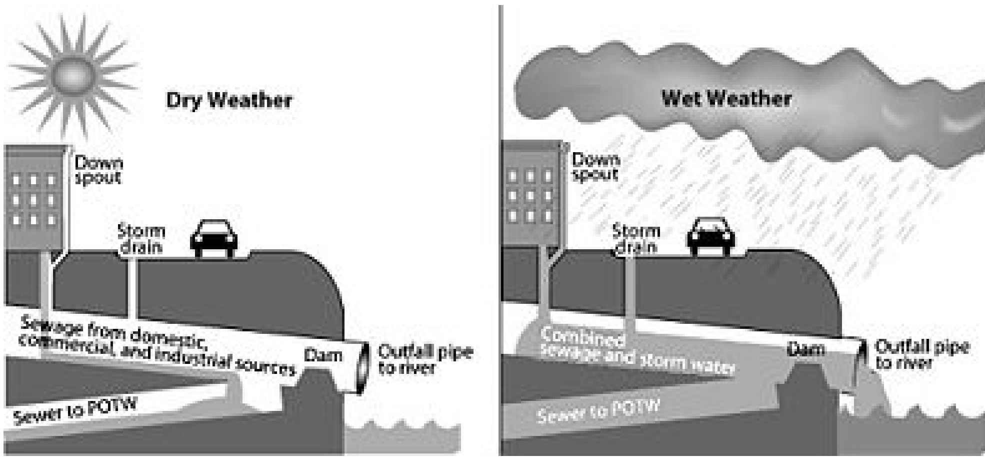
The marketing geniuses who got us to buy Aquifina should be hired by municipal water companies. Rate hikes to upgrade water infrastructure could be a much easier sell.

Wastewater Systems: From Brown to Green

In many older cities, the pipes that collect human and industrial waste also collect the stormwater runoff from streets and roofs. The rationale was economic: it is cheaper to build a single system. Cost considerations also meant the collection lines were designed to handle certain size storms.

Environmental issues weren't an issue during that time (late 19th and early 20th century.) The sewers were designed with overflow pipes that bypassed the treatment plant and channeled excess sewer water directly into a nearby body of water.

In 2004 the Environmental Protection Agency (EPA) reported that municipal wastewater systems were annually discharging an estimated 850 billion gallons of untreated wastewater and storm water into the environment. These discharges were causing an estimated 3,500 to 5,500 cases of gastrointestinal illnesses per year just at coastal and Great Lakes beaches, the EPA noted.[10]



There are about 772 communities in the U.S. with these combined sewer systems. Many have begun to look for ways to mitigate the environmental impacts. One solution is to build a separate facility to screen out solids, store, and eventually return the excess sewer water to the normal system.

The sewage, which previously flowed into the water, would flow into a large storage tank, typically underground. That tank would have the capacity to hold runoff from all but the largest storms that occur once every 100 years or less. Once the storm passes, the facility's pumps would send the retained water back into the system to be treated under the normal dry-weather process. The result of this effort is the near elimination of raw sewage flowing into the body of water.

By increasing the amount of ground cover and the natural absorption ability of soil, this "green infrastructure" process reduces the volume of runoff entering the combined sewer system. The enhanced vegetation also increases the rate at which groundwater aquifers are "recharged" or "replenished" by water in plant roots. This is significant because groundwater provides about 40 percent of the U.S. water supply.

Global Warming

Scientific evidence for global warming is persuasive. Eleven of the 12 years from 1995 to 2006 rank among the 12 warmest years since 1850, according to Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report published in 2007.[11] The year 2007 has now registered as the second hottest year, extending the trend.

Increased frequency and intensity of rainfall is one of the effects of global warming that is already apparent in meteorological records in the U.S. According to a 2007 report by the Association of Metropolitan Water Agencies on the implications of climate change for water utilities, more severe storms will likely produce more severe urban flooding, which will result in additional water pollution from a large variety of sources. Chief among these are wastewater treatment, storage, and conveyance systems.[12]

EPA research finds that, for the most part, wastewater treatment plants and combined sewer overflow control programs have been designed on the basis of the historic hydrologic record, taking no account of prospective changes in flow conditions due to climate change. As a result, it is conceivable that water systems will face higher than anticipated sewage overflows, producing high concentrations of disease-causing bacteria.

Many water utilities have begun analyze the potential impact of climate change. So-called vulnerability analyses estimate the probability that current water resource development and facility plans could be disrupted by near-term (20 to 50 year) manifestations of climate change processes. Longer-term, water utilities are projecting how environmental, socioeconomic, and engineering trends will impact their plans to cope with climate change.[13]

California water managers are particularly concerned about global warming's impact on mountain snow packs and snow-water storage, a crucial part of the state's water capacity. California's Department of Water Resources, along with the California Energy Commission, has been tracking the climate change science since the 1980s.[14]

Demand Reduction No Panacea

Daily indoor per-capita water use in a typical American single family home is 69.3 gallons. An even larger volume of residential water consumption is used outdoors. These figures do not include water used in businesses and stores.

Overall, per-capita water consumption in the U.S. is about twice as high as that in Europe.

It would be wrong to blame the nation's deteriorating water problem on profligate residential use, however. Per-capita water usage in Los Angeles has declined, for example, keeping overall water demand flat for the past two decades. "The problem," according to Steven Erie, an expert on water supply issues in Southern California, "is that we're now talking about adding two and a half new Chicago's to Southern California. Just the sheer numbers are going to drive up demand even with all the conservation that we've had."[15]

Population growth, fueled mainly by immigration, has forced communities in Southern California, Colorado, and elsewhere to buy up water rights formerly allocated to agriculture.

Nationally, less than 10 percent of water use is residential. About 35 percent is agricultural and 55 percent is industrial, including power generation. In California, 80 percent of treated water goes to irrigate crops.

Water and Energy

Pumping water is very energy intensive. This is especially true in the west, where water is conveyed over long distances through mountain terrain, and consumed in sprawling urban areas. The Metropolitan Water District of Southern California estimates that as much as 33 percent of the average household's electricity use comes from the energy embedded in water use. Nationally, water systems account for an estimated 3 percent of total electricity demand.[16]

Electric power companies are a major source of greenhouse gas emissions.

Implication: Global warming is both a cause and a result of the increased demands placed on water infrastructure.

Recycled Water

Recycled water is sewage that has been treated to remove solids and certain impurities and used for irrigation and other "nonpotable" purposes. Absorbed into the roots of plants and crops, this water eventually flows into underground acquifers. This is not a new concept: Los Angeles County has been using recycled water for parks and golfcourses since 1929. There is controversy over possible health and environmental effects, however.

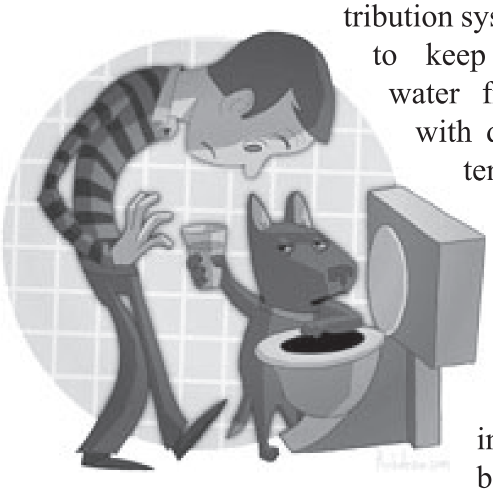
The solid material—called sludge—is also treated to a point where it is deemed safe for agricultural use. No matter how well treated, the sludge still contains rseidual amount of chemicals and bacteria. This reality has created conflict between federal regulators and the food industry:

> When EPA first promulgated criteria for land application of municipal wstewater sludges to cropland in 1979, some food processors questioned the safety of selling food crops grown on sludge-amended soils and their liability. In response, the principal federal agencies involved—EPA, the Food and Drug Administration (FDA), and the U.S. Department of Agriculture (USDA)—developed a Joint Statement of Federal Policy in 1981 to assure that current high standards of food quality would not be compromised by the use of high quality sludges and proper management practices.
>
> Nevertheless, the food processing industry remains concerned about safety and market acceptability, and at least one company has adopted an official policy that bans the purchase of any crops grown on fields receiving municipal sewage sludge or treated municipal wastewater.[17-]

By and large, the public accepts using recycled wastewater for nonpotable urban uses such as watering parks and highway medians, car washes, and industrial processing. Agriculture is a tougher sell: Less than one percent of water used on farms is thought to be from treated wastewater.

Water recycling increases the supply of drinking water since less potable water is diverted to non-potable uses. There are two big problems with such projects, however.

First, they require laying an entirely new distribution system in order to keep nonpotable water from mixing with drinking water. The second set of pipes is expensive to lay, in part due to the need to install costly backflow prevention devices at each hookup to keep recycled water out of drinking water lines.



The second problem is gravity. The logical place to site a water recycling facility is next to a sewage plant—but sewage plants almost always are located at a city's lowest elevation because that allows waste to get there by flowing downhill. As a result, using reclaimed water for irrigation typically means spending quite a bit on electricity to pump it back uphill.

These complications, combined with growing worries of water shortages, have convinced some utilities to take the next logical step: treat wastewater so thoroughly that humans can drink it.

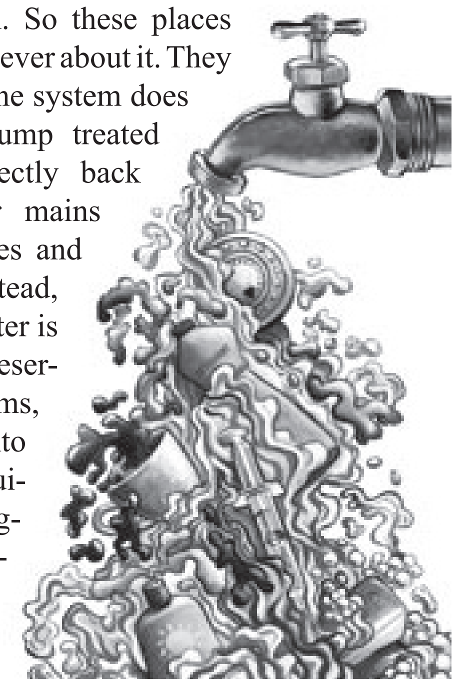
"Toilet-to-Tap"

No one wants to drink water from their toilet. But in a water crisis, you can not be picky. Case in point: San Diego, where 90 percent of the city's water already comes from faraway sources in the Colorado River and Northern California. Those supplies are soon to be off limits, as neighboring states enforce their water right claims and federal-state agreements to preserve wildlife habitat are implemented. Pacific Ocean desalinization, once thought to be the city's best alternative, foundered on the rocks of technical and cost considerations.[18]

So in late 2007, San Diego's city council authorized—over the Mayor's veto—a pilot project to test the feasibility of pumping highly treated wastewater into one of the city's drinking water reservoirs. Council President Scott Peters explains: "We're not really in a position to turn our noses up at any potential source of water."[19]

San Diego is one of a small but growing number of drought-prone communities that are turning to a once-unthinkable option for drinking water. Just north of San Diego, in Orange County, toilet water is sent through $490 million worth of pipes, filters, and tanks for purification. The water then flows into lakes in nearby Anaheim, where it seeps through clay, sand, and rock into aquifers in the groundwater basin. Months later it travels back into the homes of Orange County residents, to be used for drinking, showering, and cleaning.

It is a smart idea, one of the most reliable and affordable hedges against water shortages. But San Diego and Orange County are acting out of desperation. Studies show that most Americans reject the notion of indirect potable reuse (IPR)—or "toilet-to-tap," as its opponents would say it. The "yuck" factor present a daunting public relations problem. So these places have had to be clever about it. They focus on what the system does *not* do, i.e., pump treated wastewater directly back into the water mains that serve homes and businesses. Instead, the recycled water is pumped into reservoirs and streams, or injected into groundwater aquifers, thus recharging their freshwater sources by mixing all of the water



together. Supporters don't call it toilet-to-tap. Orange County has labeled its process "groundwater replenishment."

Are there health risks? You bet. But a recent analysis of San Diego's current (non-recycled) drinking water found several contaminants, including ibuprofen, the bug repellent DEET, and the anti-anxiety drug meprobamate. No treatment system is 100-percent reliable. Skeptics who worry that pathogens in sewage water will make it past treatment and into our drinking water should worry about all drinking water, not just the water in a toilet-to-tap program.

The fact is that supertreated recycled water is safe to drink right after treatment. It has been used safely this way (in a process known as *direct potable reuse*) for years in the African nation of Namibia. EPA researchers in Denver and San Diego found recycled water is often of better quality than existing drinking water. Although putting water into the ground, rivers, or lakes provides some additional filtering and more opportunities for monitoring quality, the benefits of doing it that way are largely psychological. In a 2004 report on the topic, the EPA concluded that Americans perceive this water to be "laundered" as it moves through the ground or other bodies of water, even though in some instances, according to the report, "quality may actually be degraded as it passes through the environment."[20]

The upfront costs of a "toilet to tap" system are steep. But it could forestall even larger costs—economic and environmental—of finding another river or lake from which to divert water.

Toilet Technology to the Rescue?

How to alleviate the demands placed on water infrastructure? The bathroom is a good place to start. Toilets use more water than any other household device. More than one-fourth (26.7 percent) of the 69.3 gallons of water used daily in an average American family home are flushed away. Clothes washers (21.7 percent) and showers (16.8 percent) are second and third, respectively. [21]

We spend billions of dollars pumping water into our homes. Then we foul it and spend billions more making it clean enough—we hope—to discharge into our lakes and rivers. This flush-and-forget cycle is destructive to local governments and the environment, and some environmentalists say we can break it with composting toilets.

The composting toilet's mechanics are simple. The waste, via gravity, drops into a pipe leading to a composter unit installed in the basement. There it is left to decompose naturally, aided by bacteria, fungi, and time. Wood chips are added about once a month to aid aeration and prevent the compost from becoming too dense.

About 100 gallons of dark, liquid fertilizer, along with several bushels of solid compost, is produced per person each year. Some composting enthusiasts spray the liquid on "wastewater gardens" they plant on soil lined with plastic sheets. The plastic leaves the liquid compost no where to go but up through the plants, which filter and evaporate it.[22]

The solid residue is removed from the bottom of the composter. It is reportedly safe to handle and has no odor.

While not exactly no muss, no fuss, the composting toilet has advantages. It does not use any water and is maintenance free compared to conventional systems. Unlike septic tanks, composting toilets do not have to be flushed out every few years. And no organic material ends up in the soil where it can carry *E. coli* bacteria, drugs, and hormones from human waste into groundwater.

> **Compare this to the sewerage treatment system, where we disrupt our ecosystems," observes Greg Allen, a building engineer and environmentalist. "In the past few years, thinking has changed around food. People realized the importance of growing food locally, for example. I think as food shortages develop because of the poor conditions of the fields—fields that are actually dead—we may see acceptance of the compost toilet, which has the potential to be part of the solution.[23]**

Composting toilets are not compatible with urban high rises. But at the fringes of metropolitan areas, where urban sprawl has outpaced the reach of municipal sewer system, they make a lot of sense. ■

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