

The Memphis Sand aquifer: A buried treasure

The Commercial Appeal-Dec 16, 2016

<http://www.commercialappeal.com/story/news/environment/2016/12/16/memphis-sand-aquifer-buried-treasure/93814278/>

The aquifer supplying Memphis with high-quality drinking water is in good shape for now, but future threats loom.

[Tom Charlier](mailto:tom.charlier@commercialappeal.com), tom.charlier@commercialappeal.com

Deep beneath a small metal shed that stands like a rusted, antenna-crowned curiosity piece in Peabody Park in Central Gardens, something strange, something unprecedented, is happening.

The structure covers a well that was drilled nearly 500 feet into the earth and, like a giant thermometer, protrudes into the Memphis Sand aquifer to monitor the health of the 40 million-year-old geologic strata that supplies the city with some of the world's finest drinking water.



The Memphis Sand aquifer provides some of the best drinking water in North America, but what is it? Jason Viera/The Commercial Appeal

When the well was drilled in the 1920s, the water in it rose to within 70 feet of ground surface, but the level dropped precipitously in the decades that followed as Memphis grew ever bigger and thirstier. By 1990, the distance to water had doubled to almost 140 feet.

During the past several years, however, the water level in the well has been creeping steadily upward. Today, the water is only about 100 feet below ground —and it’s rising still.

Across much of Shelby County, water levels in the Memphis Sand are recovering as a result of historic declines in consumption made possible primarily by more efficient household appliances and reduced industrial use. Pumping by the Memphis Light, Gas and Water Division has fallen by some 30 million gallons a day – 20 percent —since 2000.

A large footprint

The Memphis Sand is part of a larger aquifer system underlying parts of eight states and encompassing an area larger than Lake Ontario.

Water-level change from predevelopment to 2007

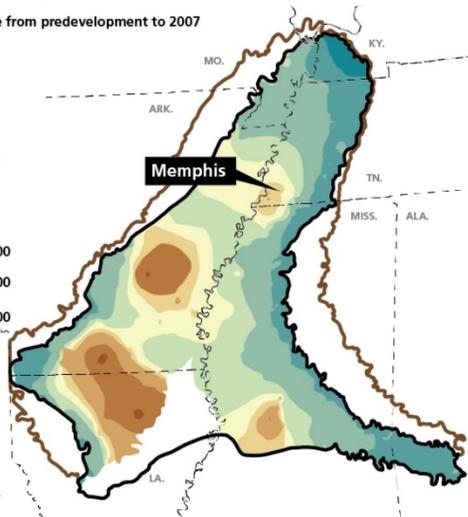
IN FEET



Study area boundary

Source: U.S. Geological Survey

KENT TRAVIS / USA TODAY NETWORK - TENNESSEE



Footprint of the aquifer system.
(Photo: Kent Travis)

“What we’re seeing is a response to reduced pumping in Shelby County,” said Michael Bradley, a groundwater hydrologist with the U.S. Geological Survey. “Compared to even 10 years ago, it looks better than it ever has.”

The Memphis Sand, by any measure, is healthy and bountiful now. But that’s not to say it doesn’t face an array of threats, some impossible to predict.

[The approval last month of well permits allowing the Tennessee Valley Authority to withdraw 3.5 million gallons of water daily to cool a power plant](#) being built in Memphis raised concerns about whether heavy pumping in certain locations could pull shallower, less-pure water into the Memphis Sand.

“What we’re seeing is a response to reduced pumping in Shelby County. Compared to even 10 years ago, it looks better than it ever has.”

Michael Bradley, a groundwater hydrologist with the U.S. Geological Survey

Memphis also faces a lawsuit now before the U.S. Supreme Court in which the state of Mississippi claims MLGW wells have altered the flow of aquifer water, pulling more of it northward across the state line. Losing that suit could result in Memphis paying \$615 million in damages and having to turn to the Mississippi River to get some of its water.

In addition to the pumping by the municipal water system, the aquifer is stressed by scores of private wells. Four existing industrial facilities in Shelby County have wells pumping as much or more than TVA's planned level, with the largest of them, Chemours, withdrawing an average of 12 million to 18 million gallons daily during 2015, according to state data. Several country clubs pump hundreds of thousands of gallons daily to irrigate golf courses.

LARGEST WATER CONSUMERS WITH PRIVATE WELLS

Daily usage during 2015, in million gallons, based on minimum and maximum monthly totals.

- *Chemours - 12.1 to 17.7*
- *KTG-USA - 6.6 to 7.7*
- *Solae - 2.8 to 4.8*
- *Memphis Cellulose - 2.9 to 4.4*
- *Penn A Kem - 1.6 to 2.93*
- *Blues City Brewery - 0.35 to 0.44*
- *Colonial Country Club - 0 to 0.27*
- *TPC at Southwind (well at #12) - 0.003 to 0.23*
- *TPC at Southwind (well at #3) 0.003 to 0.17*
- *Big Creek Golf, LLC - 0.004 to .0.145*

And although the Memphis Sand is arguably the city's greatest natural resource – a buried treasure in the truest sense – local officials generally agree there are few laws and regulations protecting it from the kind of assaults inflicted on other major aquifers across North America.

From Cape Cod to California's San Fernando Valley, public water systems are dealing with aquifer contamination or depletion problems. In Canada, bottled-water producers are pumping millions of gallons daily of pristine groundwater, while in the Great Plains water rights have been auctioned off or, in one case, held by a tycoon who planned to sell water to cities whose supplies were running out.

More than 100 million Americans rely on aquifers for drinking water, but it's doubtful that few others enjoy the quality found in Memphis.

An underground great lake

To understand the breadth, depth and magnitude of Memphis' underground water resource, imagine Lake Ontario lying 350 to 1,000 feet below Memphis. That's the size, about 7,500 square miles, of the aquifer system known to geologists as the middle Claiborne, which includes the Memphis Sand, known alternately as the Memphis Sands or the Memphis aquifer.

"It's one of the best (aquifers) in the world in terms of thickness, aerial content, quality of water," said Roy Van Arsdale, professor of geology at the University of Memphis.

The discovery of the aquifer in 1887 delivered Memphis from chronically unsafe and unreliable water sources, including cisterns, shallow wells and the Wolf River, just as the city was recovering from the Yellow Fever epidemics of a decade earlier.

"It's one of the best (aquifers) in the world in terms of thickness, aerial content, quality of water."

Roy Van Arsdale, professor of geology at the University of Memphis

Scientists believe the aquifer's formation can be traced to the movement of continental plates 100 million years ago. What is now the south-central United States passed over a "hot spot" deep in the earth, causing the crust to bulge upward. Wind and erosion then peeled away thousands of feet of soil and rock off the exposed dome, which later sank and left a deep, thumb-shaped depression known as the Mississippi Embayment extending from the present location of southern Illinois to the Gulf of Mexico. About 40 million years ago, a river that was a predecessor to the Mississippi flowed through it, depositing sand that eroded from what is now the Midwest. The deposits included the fine-grained sands that form the aquifer.

The middle Claiborne aquifer system spans parts of seven states. The Memphis Sand portion of the system is at its thickest, about 800 feet, near the Mississippi River, where it stores mind-boggling amounts of water – an estimated 57 trillion gallons beneath Shelby County alone. To envision how much that is, if a gigantic wall surrounded the county and the water was brought to the surface it would cover Shelby to a level equal to the top of 400-foot-tall Clark Tower.

Ancient source of water

Through studies of the hydraulic gradient — the slope of the aquifer — scientists have been able to ascertain the age of the water with relative certainty.

"Two to three thousand years is a good average," said Brian Waldron, director of the U of M's Center for Applied Earth Science and Engineering Research.

That means the water fell as rain at about the time Alexander the Great was conquering Egypt, or when Confucius was espousing his principles of family loyalty and respect for elders.

After falling on the aquifer recharge area of Fayette County and eastern Shelby County, the rain drops percolated downward and then began seeping west toward the Mississippi, moving

mere inches a day. Along the way, the sand layer acted as one continuous filter, removing impurities and solids.



Roland Person, supervisor of water operations for Memphis Light, Gas and Water, walks through the basement of the water filtration system at the Sheahan pumping station in this July 2015 photo.
(Photo: Mike Brown/The Commercial Appeal)

The water from the Memphis Sand is not just highly pure, it's cheap. To treat the water, MLGW merely aerates and filters it to remove naturally occurring iron, then disinfects the water and adds tooth-strengthening fluoride and a phosphate to prevent pipe corrosion.

Because of that low level of treatment, MLGW offers residential water rates that are among the cheapest in the nation, with only Orlando, Florida, charging less in a recent survey of nearly three dozen utilities. The quality of the water has attracted beer breweries, pharmaceutical producers and other firms to Memphis.

“Our laboratory personnel are very confident that we in Memphis have the best drinking water in the country,” said MLGW President and CEO Jerry Collins.

Threats to the aquifer

Intense pumping of the aquifer, however, has caused problems over the years. In 1887, when the Bolen-Huse Ice Co. first tapped the Memphis Sand with its 354-foot-deep well Downtown, the water was so abundant and under such pressure that it rose like a fountain several feet above ground. By 1928, however, the level there had dropped 33 feet.

Between 1928 and 1983, a period in which Memphis' population grew from about 250,000 to 650,000, pumping increased so dramatically that the water level of wells in the aquifer fell at

rates of up to 1.3 feet per year. At some wells, total declines of 100 feet or more threatened to draw the water table so low that the sand in the aquifer would begin to compact, causing irreversible damage.

Aside from over-pumping, contamination has posed a salient threat in recent decades. Most of the aquifer is protected from surface contaminants by the thick clay layer that settled over the Memphis Sand when sea levels receded. But since the 1980s, scientists have been discovering gaps, or windows, in the clay caused by ancient faults and erosion gullies.



An excavator works in front of the new Allen Combined Cycle Plant being built in August 2016. (Photo: Nikki Boertman/The Commercial Appeal)

The windows have been mapped in locations ranging from Shelby Farms to Presidents Island. Several are located near MLGW well fields.

The openings allow for young water to trickle into the Memphis Sand from a shallow aquifer and mix with the old water. By testing water for tritium and other compounds traceable to the nuclear age, scientists confirmed the presence of water as young 13 years old in the aquifer. This is concerning to scientists and local officials because the young water tends to be of poorer quality — higher in dissolved solids — and vulnerable to surface contamination.

That threat of pollution is more than theoretical. During the late-1980s, three wells in MLGW's Allen well field turned up trace levels of industrial organic compounds, although no customers received water that violated health standards. A similar discovery occurred in 2009, when three other wells in the Allen field were shut down after water was found to contain minute amounts of cancer-causing benzene.

In some wells in MLGW’s Davis well field in Southwest Memphis, more than half the water pumped is of young vintage, Waldron said. And despite the years of mapping and studies, researchers believe there are more windows they have yet to discover.

“Worse yet, we don’t know much about their (the windows’) characteristics – how fast water moves through them,” Waldron said.

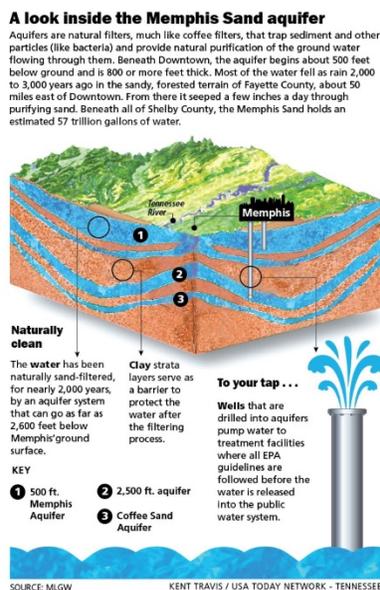
With those mysteries unresolved, researchers say it’s impossible to gauge whether the wells at TVA’s Allen Combined Cycle Plant in Pidgeon Industrial Park present a serious threat to the aquifer. A USGS study found that the 3.5 million-gallon-per-day withdrawal at the plant won’t significantly affect water levels in the aquifer, but it didn’t address the possibility that the pumping could pull less-pure water into the Memphis Sand from windows on nearby Presidents Island or ones possibly situated along the Mississippi.

Regulatory protection lacking

The county Groundwater Quality Control Board on Nov. 30 approved the TVA permits – rejecting an appeal filed by the Sierra Club – after determining that the agency had shown a need for the wells and that its application met standards set by local regulations. The Health Department's initial approval of the permits had been proper, it found.

But many local officials argue that the county’s regulations are hardly adequate to protect the Memphis Sand and other aquifers. At 30 pages, the well rules are just a fraction of the size and scope of the 512-page Unified Development Code, which covers local zoning and land-use guidelines.

“We definitely need a better process in place for permitting wells, so whether somebody is able to put in a well is not determined by whether they check all the boxes,” Collins said.



A look inside the Memphis Sand aquifer.
(Photo: Kent Travis)

The rules outline construction standards, prohibit certain practices as wasteful and set requirements for well-monitoring and closure. They also set siting criteria, prohibiting, for instance, the drilling of wells within 100 feet of manure piles and septic systems.

But the ordinance places few restrictions on the use of water, and it doesn't require well owners to specify how much they plan to withdraw. They only have to report withdrawals to the Tennessee Department of Environment and Conservation if they're pumping at least 10,000 gallons daily.

In addition, the current rules don't provide for public notification of well applications or approvals. Even with such a large project as that planned by TVA, the groundwater board — established in 1990 to "secure, protect and preserve" the quality and quantity of water beneath the county's borders — was not asked to fully review the proposed permits.

There's nothing in the Shelby regulations to prevent a company from pumping millions of gallons daily to produce bottled water, as Nestle is doing in Ontario. And there's no agency protecting the Memphis Sand like, say, the Edwards Aquifer Authority in Texas, which closely manages withdrawals from a famed, high-quality aquifer used by San Antonio and other cities. Also missing is the kind of source-water protection program employed for the Great Miami River Buried Valley Aquifer, which serves the Dayton, Ohio, area.

* * * * *

OTHER URBAN AREAS USING AQUIFER WATER

- *Dayton, Ohio: Water supply comes from the Great Miami River Buried Valley Aquifer*
- *Miami, Florida: Pumps water from the Biscayne Aquifer*
- *Jacksonville, Florida: Uses the Floridan Aquifer*
- *Nassau and Suffolk counties, New York: Uses the Upper Glacial, Lloyd and Magothy aquifers*
- *San Antonio, Texas: Formerly obtained all its water from the Edwards Aquifer, but now supplements its supply with other groundwater and surface water sources.*
- *Spokane, Washington: Uses the Spokane Valley-Rathdrum Prairie Aquifer.*

* * * * *

"We need to take the groundwater resources of the county more seriously," said Scott Banbury, conservation programs coordinator for the Sierra Club's Tennessee chapter.

He said efforts like those by billionaire oil tycoon T. Boone Pickens, who once planned to put in a pipeline in Texas and sell aquifer water to faraway cities at hefty prices, are likely to become a "more prevalent" threats to water resources here and elsewhere in the future.

“We need to take the groundwater resources of the county more seriously.”

Scott Banbury, conservation programs coordinator for the Sierra Club's Tennessee chapter

For all those hazards, however, the Memphis Sand is more robust now than at any time in recent decades, and the reasons have little to do with local policy.

Total groundwater withdrawals in Shelby County – including pumping by municipal systems, industries and others -- declined from an average of 218 million gallons daily in 2000 to 187 million gallons in 2014, according to TDEC figures.

MLGW last year pumped an average of 126 million gallons of water daily, down from 158.8 million gallons in 2000. The average residential household served by the Memphis utility now consumes 770 cubic feet of water per month, a 35 percent drop from usage in 2000. The trend has continued through wet years and dry ones.

The driving force in the decline has been the dramatic increase in the efficiency of household plumbing and appliances, Collins said. Modern low-flow toilets now use about one-fourth of the 6-gallons-per-flush consumption of older models, while newer faucets and clothes-washers use about 30 percent and 40 percent less water, respectively, than older ones.

“We’ve actually seen that trend nationwide. Withdrawals for public supplies are decreasing,” Bradley said.

As a result of the local consumption declines, water levels in many monitoring wells in the Memphis Sand have risen 10-40 feet in recent years, a review of well data shows.

To MLGW’s Collins, that means one thing: “The aquifer is becoming healthier.”