The Virginian-Pilot

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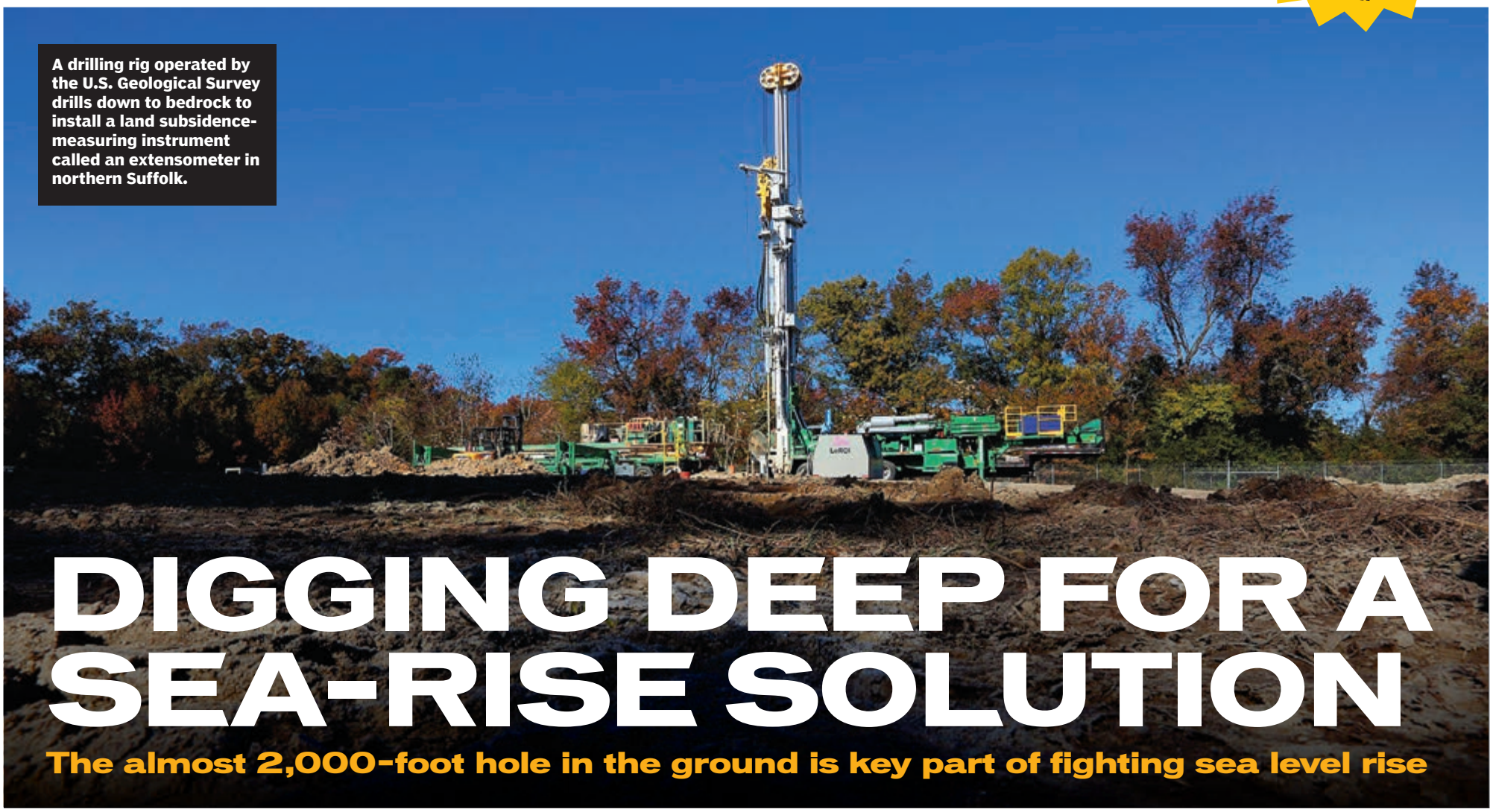

A drilling rig operated by the U.S. Geological Survey drills down to bedrock to install a land subsidence-measuring instrument called an extensometer in northern Suffolk.

STEVE EARLEY | THE VIRGINIAN-PILOT

DIGGING DEEP FOR A SEA-RISE SOLUTION

The almost 2,000-foot hole in the ground is key part of fighting sea level rise

By Dave Mayfield
The Virginian-Pilot

SUFFOLK

JUST EAST of Interstate 664, about as far north in this city as you can get, there's a hole in the ground. A deep, deep hole. Almost 2,000 feet. All the way to bedrock and beyond.

A monster of a drilling rig needed just a couple of weeks to get there, boring through clay, sand and shell that took nature millions of years to layer.

This week, the drillers plan to begin using their big machine to nudge section after section of protective casing down into the hole, all the way to the bottom. Inside it, they'll put even more pipe for a special device.

The work could take weeks more, and the cost will easily top $1 million.

To the crack team of U.S. Geological Survey drillers, it's just another well. They travel the country to bore many types of them for researchers.

But in Hampton Roads and coastal regions elsewhere, scientists have taken an

See **DRILLING, PAGE 14**

Old friends remember Bannon as bright, kind in school

KIMBERLY PIERCEALL | THE V-P

Stephen Bannon, seen in high school in 1971, was born in Norfolk. He's adviser to President-elect Donald Trump.

By Kimberly Pierceall
The Virginian-Pilot

For son with autism, family finds purpose in service

Parents combine young man's love of running and car rides to help others

DRILLING

BENT ROD GIVES SCIENTISTS HOPE

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extraordinary interest in this hole in Suffolk. This well will provide the framework for an instrument, known as an extensometer, that will help answer an important question: Could there be a way to help stave off sea level rise?

It's no coincidence that several hundred yards away, something else is in the works. The Hampton Roads Sanitation District recently drilled another well. A little more than a year from now it plans to begin testing a theory there: that injecting water from its treatment plants into a huge aquifer deep beneath the surface will slow and eventually reverse the sinking of land throughout the region.

Scientists factor in this sinking, known as subsidence, when calculating what's known as relative sea level rise. And in Hampton Roads, they say, the ground may be sinking as fast in some places as the Atlantic Ocean is rising.

That combination makes for a big threat. Only New Orleans, which also is experiencing dramatic subsidence, is considered more vulnerable among U.S. metro areas to rising seas.

So when HRSD begins injecting a million gallons a day of treated wastewater into the ground at its Nansemond plant in early 2018, the big question will be: What's that extensometer just around the corner saying?

Will it indicate that the land near the injection well is starting to rise? Will it show what many folks who support HRSD's plan are hoping: that we can slow the threat of the sea coming at us by rehydrating and reinflating the ground deep beneath us?

Ted Henifin, HRSD's general manager, will bet you $1 billion that the answer is yes. That's how much the agency plans to spend converting seven of its plants into aquifer-replenishment centers, if the demonstration at the Nansemond facility goes well.

It's a project known as SWIFT – Sustainable Water Initiative for Tomorrow. By 2030, the plants could together be pumping as much as 120 million gallons a day into the Potomac aquifer, all of it treated to drinking-water-quality standards.

Henifin said HRSD likely would pursue the project even if it didn't help with subsidence. He said recharging the aquifer would benefit groundwater users, and HRSD's discharges of treated, but still polluted, water into the Chesapeake Bay and its tributaries would all but cease.

Still, Henifin said, "I'd be disappointed if we don't see something" to confirm HRSD's models showing that subsidence can be slowed. "I'm very optimistic. I'm just not sure how long it will take."

HRSD is footing the cost of the Geological Survey project and provided the land for the federal agency's extensometer and some new groundwater-monitoring wells.

To David Nelms, who's helping oversee the federal role, it's a gratifying full circle in a career of more than three decades with the Survey, best known as the USGS.

Back when he started with the agency in 1984, Nelms was dispatched from Richmond down to Hampton Roads to check out a couple of extensometers. One of them was installed across the street from the former Union Camp mill near Franklin. The factory drew more than 40 million gallons a day of groundwater at the height of its paper production, more than any other user of the Potomac aquifer.

"I thought it was really cool. I was a kid straight out of college … and just the realization that pumping water out of the ground, you could see response as you looked" through the instrument's records, he said. When the mill shut down for a holiday period or because of a strike, the ground rose back – typically by no more than tenths of a millimeter, but enough to prove a correlation.

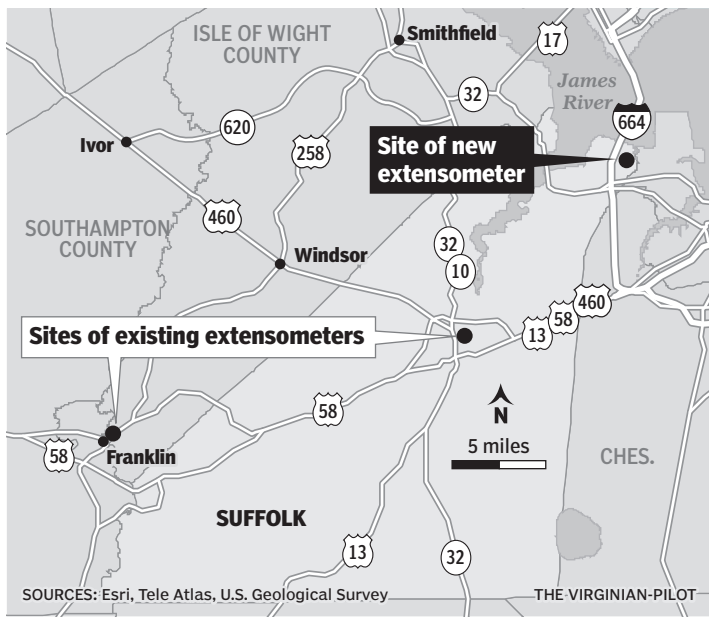
The Franklin instrument, put into operation in 1979, and another one installed north of downtown Suffolk in 1982 were the only such devices deployed by the USGS in Virginia. Their purpose was to measure the effect of the huge groundwater withdrawals in a "cone of depression" extending out from the mill.

The USGS was first tipped off to the extent of subsidence in the region by surveyors from another federal agency who periodically measured elevations across the country. Around Franklin, "they kept having problems meeting their error tolerances," Nelms said.

STEVE EARLEY | THE VIRGINIAN-PILOT

WILL SUBSIDENCE SLOW OR REVERSE?

The U.S. Geological Survey is drilling a new well in Suffolk in which an extensometer, which measures land surface elevation, will be installed.



SOURCES: Esri, Tele Atlas, U.S. Geological Survey — THE VIRGINIAN-PILOT

"The water levels are going to go up, and that should cause the land to go up."

David Nelms, hydrologist at the U.S. Geological Survey

Sea level rise, much less subsidence's role in it, wasn't much talked about in his early days at the USGS.

In Virginia, subsidence was mostly a curiosity at that time.

Geologists said then and they still say that it's likely due in part to something known as glacial isostatic adjustment – basically, that Hampton Roads is on the lowering end of a land mass still settling after the weight of glaciers from the last ice age was lifted.

But they knew that withdrawals from the aquifer likely were playing a big role, too. Subsidence-stricken California, Texas and other states where huge underground reservoirs of water or oil have been depleted offered plenty of supporting evidence.

In Virginia, droughts are comparatively rare and fresh water plentiful. So the minuscule changes in ground levels were recorded by the duo of extensometers without much notice. An ink pen traced across a sheet of paper on a roll at each site, and at least once a month, a technician replaced the sheets. The old ones went into an archive in Richmond, where they were all but forgotten.

In 1995, during a period of budget-tightening, somebody at the USGS decided the instruments weren't worth maintaining, so the record-keeping stopped.

Nelms had long before moved on to other projects, but he remembers being irked back then about the decision. He suspected that if somebody ever found the time to dig into the history kept by the extensometers, he might find a story worth telling.

Nelms and fellow USGS hydrologist George Harlow found that somebody in the early 2000s when a former colleague at the agency took a faculty position at Virginia Tech. Thomas Burbey told them about a grad student named Jason Pope who was rummaging for research topics.

Have him comb through all those extensometer records, Nelms and Harlow suggested. Within a year, Pope had uncovered enough to lead-author a paper in a scientific journal. He'd added up rates of aquifer compaction – essentially, subsidence – averaging about 1.5 millimeters a year in Franklin and 3.7 millimeters a year in Suffolk during the periods in which the extensometers were in operation. The aquifer is much deeper in Suffolk.

It took a while for others to appreciate the implications of Pope's findings. If that compaction rate continued over a century, there'd be more than a foot of subsidence around downtown Suffolk. Figure that subsidence due to aquifer drawdowns was occurring not just there, but throughout the region. Then factor in predictions of an accelerating global rate of sea level rise – to two, three, four feet or more over the next hundred years – and it was becoming easier to get the big picture.

Clearly, Hampton Roads had a problem.

In the decade since, severe flooding events in Franklin and elsewhere in the region have loudened the subsidence alarm, and nuisance flooding in Hampton Roads' lowest-lying parts have increased the reminders. All it takes now in more and more places is a full moon and high tide to swamp intersections and isolate neighborhoods.

Still, the old extensometers in Franklin and Suffolk sat gathering dust in the metal sheds where they'd been installed. Like lonely sentinels without anyone to report to, they were checked by nobody at the USGS.

Then a year or so ago, Nelms and some colleagues began talking with Hampton Roads planners about whether the instruments could be put back in service. In the summer of last year, Nelms and a few others went out to take a look. In Franklin, they got more than they bargained for: Even without paper and ink, the instrument was still recording.

Nelms carries the evidence in the cab of his pickup, and he fished it out for a recent interview. It's a crooked, threaded steel rod. It had been part of the extensometer mechanism, and something happening in the ground beneath it had caused it to bend.

Something apparently not considered likely when the instrument was put in: Sometime between 1995 and 2015, the ground around Franklin had started steadily rising.

Enough that the casing for the extensometer pipe that went down into the ground pushed up the support post for a fulcrum that was connected to the threaded rod. The pressure was enough to bend the rod.

Calculating the angle of the bend and then applying simple geometry, Nelms figured the ground had rebounded by at least 27 millimeters, about an inch. Pope, who'd joined and stayed with the USGS after college, applied his own model and came up with a number that was nearly double that.

It didn't take long for the scientists to speculate on a link: the Franklin mill. Its groundwater pumping all but ceased with its shutdown by International Paper in 2010. Though parts of the mill reopened over the next several years, the withdrawals are just a fraction of their former level.

When HRSD's Henifin got a look at that bent rod, "it was a confirming moment," he said. "It helped me believe that our models" showing that a large percentage of the subsidence due to aquifer compaction could be reversed.

The USGS re-equipped the two old extensometers in February, and the data they've collected since then have further boosted Henifin's confidence.

It shows that in Franklin the land surface is still rising, at a rate now that's equivalent to about 1 millimeter a year, Nelms said. Near downtown Suffolk, though there's still subsidence, it has slowed to about 1.8 millimeters a year, less than half the annual average measured when the extensometer there was previously in operation, from 1982 to 1995.

Nelms said the Franklin mill's demise is the only obvious link to the changes.

In his trailer at the site where the new extensometer will go, there's a big poster that explains how the instruments work and what's been happening lately at the other two locations.

Over the rumble of the drilling rig, Nelms said he expects the instrument in northern Suffolk will be ready to start collecting data sometime early next year. That's assuming the drill crew doesn't have to abandon the hole, as it was forced to do with another one after some pipe and casing jammed deep beneath the surface.

Extensometers record everything electronically now, without paper and ink. The plan is to continuously display the new instrument's readings – and those of the other two – online for anyone to see.

Nelms said he is well aware that this is not just another science project, with the billion-dollar initiative HRSD has in mind.

"The scale of this thing is so large, the potential so large," he said.

Because of that, the USGS wants to collect a year's worth of data at the new site before the aquifer-injection demonstration begins. Everything suggests that when that experiment starts, Nelms said, "the water levels are going to go up, and that should cause the land to go up."

But, he said, "Nature can be sloppy sometimes, so until you really do this, do the measurements, you won't know. It could be pretty amazing what we'll be able to see."

The U.S. Geological Survey wants to collect a year's worth of data before the aquifer-injection demonstration begins. If that goes well, Hampton Roads Sanitation District plans to spend $1 billion to convert seven plants into aquifer-replenishment centers.

Dave Mayfield, 757-446-2341, dave.mayfield@pilotonline.com