The 2011 Summer Field Conference Demonstration

DRILLING A LARGE-DIAMETER TOP-HOLE

By Todd Giddings, Ph.D., P.G., PGWA Education Committee Chairman

Public water-supply wells, high-yield industrial wells, irrigation wells, and Marcellus Shale gas well top-holes all start with a large-diameter hole (20 to 24-inches) in which is then set the surface or starter casing (16 to 20-inches in diameter). With the dramatic increase in the number of Marcellus Shale gas wells that are being drilled, there has also been an increase in the concern by the general public about protecting the quality of Pennsylvania's groundwater supplies. To address these concerns, the Pennsylvania Ground Water Association demonstrated the proper method of constructing a large-diameter top-hole in June, 2011.

Laibe Corporation provided their Versa-Drill® V-200NG air-rotary drill rig to drill a 20-inch diameter and a 6-inch diameter borehole. Center Rock, Inc. provided their 20-inch

This Center Rock 20-inch Cyclops™ button bit was use to drill the top hole.

Cyclops™ button bit and their CR120 (12-inch diameter) down-the-hole hammer. The piston in this huge hammer weighed a whopping 304 pounds, and an auxiliary air compressor (on a second drill rig provided by Duane Moyer Well Drilling, Inc.) was use to provide the 2,300 cubic feet per minute (cfm) of air to operate the CR120 down-the-hole hammer. If you were standing within 20 feet of the drill rig when the CR120 down-the-hole hammer started to drive the Cyclops™ 20-inch diameter bit, you could feel the ground vibrating under your feet.

The annular space between the 4 ½-inch diameter drill rod and the 20-inch diameter borehole was more than 2 square feet, so a volume of air greater significantly more than the 2,300 cfm available was needed to carry the rock chips out of the borehole. Baroid Industrial Drilling Products provided their QUIK MUD® D-50 polymer and their AQF-2™ foaming agent that were mixed with water and then injected into the air stream to create "stiff foam". The QUIK MUD® D-50 polymer kept the rock dust and chips from sticking together, and the AQF-2™ foaming agent formed air

The Cyclops™ bit is mounted on this 12-inch diameter Center Rock CR120 down-the-hole hammer that has a piston that weighs a whopping 304 pounds.

bubbles the increased the ability of the air stream to lift the rock chips out of the borehole.

The "stiff-foam" worked very effectively to carry the rock chips out of the borehole and created a large mass of foam around the back of the drill rig. When "stiff foam" is used for many hours of drilling, a huge "cake" of foam builds up around the back of the drill rig. Because a huge foam "cake" is very persistent and difficult to move or dissipate, it quickly interferes with drilling activities. A BubbleBuster centrifuge provided by On Site Drilling Solutions was used to dissipate the foam

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Adding the AQF-2™ foaming agent to 50 gallons of a water and QUIK MUD® D-50 polymer mixture that has an increased viscosity. This 3-component liquid mixture was injected into the compressed air stream to create the "stiff foam".

The foam cake of bubbles is being pumped through the yellow hose into the BubbleBuster where injected compressed air and centrifugal force are deflating the bubbles.

cake by using compressed air and centrifugal force. A diaphragm pump was used to pump the foam cake into the BubbleBuster centrifuge, where compressed air and centrifugal force broke up the bubbles. So as fast as the foam bubbles came out of the borehole and started to form a big cake, the diaphragm pump sucked them into the BubbleBuster centrifuge where the bubbles broke apart.

A very small volume of residual foam dribbled out of the bottom of the BubbleBuster centrifuge tank.

The 20-inch borehole was drilled to a depth of 17 feet and then a few bags of HOLEPLUG® chip bentonite were poured into the bottom of the borehole and hydrated with fresh water. The HOLEPLUG® chip bentonite was used

This household well was drilled with "stiff foam" and the bubble foam cake extends more than 100 feet from the drill rig. The BubbleBuster could have prevented this mess.

The EZ-SEAL® bentonite grout slurry has been pumped down 17 feet through a tremie pipe into the bottom of the annular space around the 16-inch casing and is shown flowing out onto the ground surface indicating that the annular space is completely full of grout.

to provide a dense bentonite clay seal around the bottom of the steel casing so the bentonite grout slurry that was going to be pumped into the annular space around the 16-inch steel casing would not leak past the bottom of the steel casing.

After setting 19 feet of 16-inch diameter steel casing (provided by Morris Industries) in the borehole, a Geo-Loop, Inc. model 50-500 grout mixing and pumping unit was used to mix and pump EZ-SEAL® bentonite grout through a tremie pipe into the 2-inch wide annular space between the outside of the 16-inch steel casing and the wall of the 20-inch borehole. The tremie pipe was placed to the bottom of the annular space, causing the annular space to be filled with the EZ-SEAL® bentonite grout from the bottom up to ground level. This is the proper procedure for placing grout into the annular space by the pressure-tremie method. Bentonite grout (or any other type of grout) should never be allowed to fall through standing water. This can occur if the end of a tremie pipe is not placed all the way to the bottom of the annular space. When grout falls through standing water it is diluted and if cannot and will not provide an impermeable seal between the casing and the wall of the borehole. The impermeable seal is formed by the bentonite grout after it hydrates, which is the process where the bentonite absorbs water into its crystal structure and swells 10 to 30 times its original volume and forms an impermeable plastic gel.

After the 16-inch casing was grouted in place, a 10-inch borehole was drilled to a depth of 35 feet, again with the use of the "stiff foam". We did not have enough volume of compressed air alone to carry the rock chips out of the hole because the top 16 feet of this borehole was 16 inches in diameter (inside the 19 feet of 16-inch diameter casing). As the diameter of a borehole increases, the volume of compressed air that is needed (to create an up-hole velocity that will blow the chips up against the pull of gravity) increases exponentially. The "stiff foam" increases the capacity of the air to carry larger rock chips at a lower velocity, and hence is a very effective way to drill with a limited volume of compressed air. Stiff foam is not a well known drilling technique in the water-well drilling industry, and was an important component of this large-diameter drilling demonstration.

Next, 37 feet of 6-inch diameter steel casing with a drive shoe was installed into this 35-foot deep borehole, and the drive shoe was seated into the bedrock by driving the casing with the down-the-hole hammer. A 35-foot long tremie pipe was placed to the bottom of the 2-inch wide annular space between the 6-inch casing and the wall of the 10-inch diameter borehole. Then EZ-SEAL® bentonite grout was mixed in batches and was pumped through the tremie pipe into the annular space, filling it up to the ground surface. As the bentonite grout filled up the annular space, the tremie pipe was pulled up, while always keeping the end of the tremie pipe submerged under the surface of the bentonite grout.

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Photos by Todd Giddings

Installing the white 1-inch diameter PVC plastic tremie pipe to the bottom of the annular space between the 6-inch casing and the 10-inch borehole. A hose will connect the tremie pipe to the pump on the grout mixing unit.

Adding a 50-pound bag of dry EZ-SEAL® bentonite grout to the fresh water swirling around in the mixing tub of the grout mixing and pumping unit. Note the white tremie pipe that extends 35 feet to the bottom of the annular space between the 6-inch casing and the 10-inch borehole."

Pennsylvania has no statewide regulations requiring the proper grouting of residential water wells and geothermal boreholes. The 120,000 residents in the Nittany Valley (in Centre County, PA) where this field demonstration was conducted depend almost entirely on groundwater for their 16 million gallons per day of drinking water. To protect their groundwater quality, the municipalities enacted their own residential water well and geothermal borehole ordinance that can be reviewed and downloaded at www.crcog.net/codes . Follow the geothermal borehole and water well link on the home page to Chapter 10 in the Property Maintenance code pdf document. This demonstration well was constructed to these standards which are in effect in Ferguson Township where this demonstration well is located.

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The Pennsylvania Ground Water Association thanks the following companies and their personnel for making this 2011 field demonstration possible: Laibe Corporation (www.laibecorp.com) for providing their Versa-Drill® V-200NG air-rotary drill rig and their Geo-Loop, Inc. (www.geo-loop.com) model 50-500 grout mixing and pumping unit; Duane Moyer Well Drilling, Inc. (www.moyerwelldrilling.com) for providing the auxiliary compressor on their drill rig; Center Rock, Inc. (www.centerrock.com) for providing their CR120 down-the-hole hammer and their 20-inch Cyclops™ button bit; On Site Drilling Solutions (www.onsitedrillingsolutions.com) for providing their BubbleBuster centrifuge; Morris Industries (www.morrispipe.com) for providing the 16-inch diameter and 6-inch diameter steel casing; Baroid Industrial Drilling Products for providing their QUIK MUD® D-50 polymer, AQF-2™ foaming agent, and EZ-SEAL® bentonite grout; Edward Powell Pump and Well Drilling, Inc. (www.powellpumpandwell.com) for providing their water tank and tremie pipe; the Oscar Dearmitt Drilling and Pump Co. Inc. for providing their backhoe and a source of fresh water; and The Penn State University College of Agricultural Sciences for providing tables and chairs. To download an electronic pdf document of this article, go to www.pgwa.org .