

Title: Field Evaluation of Annular Seals in Water Wells

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Background: Unsealed annular spaces in water wells can provide pathways capable of transmitting contaminants to groundwater. Concern has recently developed about the possibility of unsealed annular spaces in Wisconsin water wells. While no case studies link unsealed annular spaces to health problems in Wisconsin, current mud-rotary drilling methods and use of drilling mud and cuttings slurry as an annular sealant pose a potential groundwater contamination and health risk. Results from a recent study indicated that water wells sealed with drilling mud and cuttings slurry exhibited anomalies characteristic of unsealed annular spaces. To ensure that annular spaces in new water wells were sealed properly, DNR officials advised mud-rotary drilling firms to begin sealing wells by pressure-injecting high solids bentonite grout, a sealant believed to be superior to drilling mud and cuttings.

Objectives: The objective of this study was to assess the integrity of annular spaces in water wells sealed with pressure-injected high solids bentonite grout. In addition, the influence of type of geological formation on seal quality was sought.

Methods: A down-hole ultrasonic probe was used to evaluate seals in 18 water wells constructed in a variety of geologic environments by firms licensed to drill in Wisconsin. Ultrasonic energy was transmitted through the casing and into the annulus at regular intervals along the length of the well. Energy that reflected back to the probe was analyzed, and the annular material was determined. Profiles of annular material with depth were created for each well, and were then compared to the geological materials adjacent to the annulus.

Results and Discussion: Varying amounts of high solids bentonite grout, saturated granular material, and unsaturated granular material were discovered in each well. The largest percentage of high solids bentonite grout was 94%. The lowest was 20%. On average, the annular spaces consisted of 55% high solids bentonite grout, 34% saturated granular material, and 8% unsaturated granular material. Continuous lengths of high solids bentonite grout were detected adjacent to both coarse-grained formations and fine-grained formations, which indicates that high solids bentonite grout performs better as an annular sealant than drilling mud and cuttings slurry. Instances of formation collapse and grout channeling were also detected.

The length of sealed annulus was found to be related to the type of formation material adjacent to the annulus. Larger percentages of high solids bentonite grout were detected in annular spaces adjacent to non-caving formation materials such as

clay. In annular spaces adjacent to caving materials such as gravel, high solids bentonite grout was detected less frequently. Caving of granular material into the annulus likely precluded placement of grout. Screen development methods currently used by mud-rotary drillers displace drilling fluid from the annulus, which may lead to excessive and unintentional borehole collapse.

Conclusions and

Recommendations: The WDNR has increased the quality and safety of water wells by promoting the use of high solids bentonite grout over drilling mud and cuttings slurry. However, significant amounts of granular material with unknown hydraulic properties were detected in the annular spaces of many wells. Annular spaces in 3 out of 20 aquitards were grouted less than 6%, and potentially could act as preferential pathways for contaminants. Current mud-rotary construction techniques need to be refined to prevent granular formation material from collapsing into the annulus. The best construction procedure should be defined and subsequently validated in the field by testing with the ultrasonic probe.

Related

Publications:

Christman, M. C., Edil, T. B., and Benson C. H. (1999) "Characterization of Well Seals using an Ultrasonic Method," *Proceedings SAGEEP '99*, Symposium for the Application of Geophysics to Engineering and Environmental Problems, Oakland, CA.

Yesiller, N., Edil T. and Benson, C., (1997a) "Ultrasonic Method for Evaluation of Annular Seals for Wells and Instrument Holes," *Geotechnical Testing Journal*, ASTM, 20(1),17-28.

Yesiller, N., Benson, C. and Edil, T. (1997b), "Field Evaluation of Ultrasonic Method for Assessing Well Seals," *Ground Water Monitoring & Remediation*, 169-176.

Yesiller, N., Benson, C., Edil, T., and Klima, J. (1997c) "Assessment of Cased-Borehole Seals Using an Ultrasonic Method," *Proceedings GLGGC '97*, 5th Great Lakes Geotechnical-Geoenvironmental Conference, Ann Arbor, MI, 133-152.

Key Words:

Water Wells, Annular Well Seals, Ultrasonic Probe, High Solids Bentonite Grout

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Final Report:

A final report containing more detailed information on this project is available for loan from Wisconsin's Water Library, University of Wisconsin - Madison, 1975 Willow Drive, Madison, Wisconsin 53706 (608) 262-3069.