Hydraulic testing of Dakota NGWMN wells by the Iowa Geological Survey

16 August 2022

Funded by the
U.S. Geological Survey – Award # G21AC10430
15 July 2021 – 14 July 2022

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INTRODUCTION

The National Ground-Water Monitoring Network (NGWMN), which was established to assess long-term water-level and water-quality trends at a national scale, provides a unique opportunity to collect and share data from different states and agencies. The Iowa Geological Survey (IGS) at the University of Iowa joined the NGWMN in 2017. The IGS contributes 40 wells, completed in the Cambrian-Ordovician (USGS national code S300CAMORD), Cretaceous (N300lLCRTCS), Mississippian (N500MSSPPI), and Silurian-Devonian (N400SLRDVN) aquifers, where quarterly static water level measurements are reported to the NGWMN.

Many of the IGS wells are decades old and lack documentation of when (or if) water was last purged or if hydraulic tests were ever conducted. Through U.S. Geological Survey (USGS) Award # G21AC10430 the IGS received funding to pump water and conduct hydraulic tests on five Cretaceous (Dakota) NGWMN wells. This report describes the work performed and results obtained under this award.

WELLS

The IGS received funding to pump water and conduct in situ hydraulic tests on five Cretaceous (Dakota) NGWMN wells. A sixth Cretaceous well was added for pumping and hydraulic testing during the project. Figure 1 shows the locations of the wells. Appendix A contains more detailed information on the wells. IGS paper records do not indicate when the wells were last purged or if slug, or other hydraulic tests, have ever been conducted on the wells.

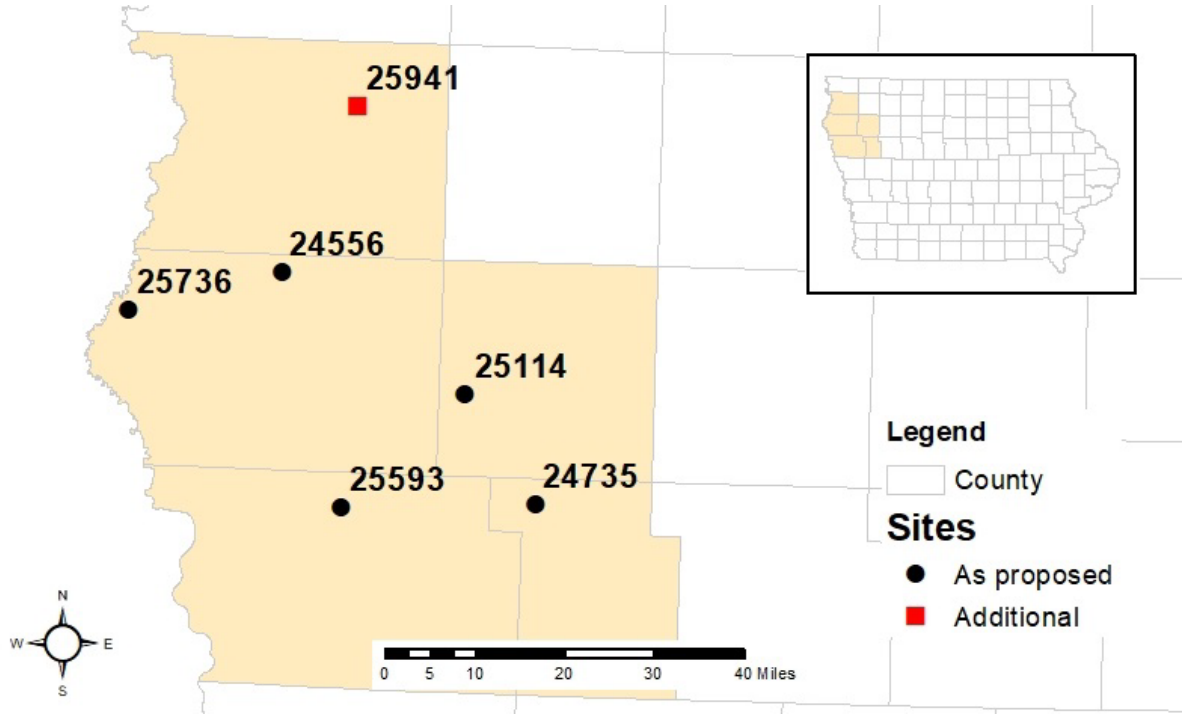

Figure 1. Location of wells selected for pumping and hydraulic testing.

WELL PUMPING

Water from five wells was purged in the fall 2021 and one well in early 2022. The initial plan was to purge three well volumes of water, calculated using the casing diameter, total well depth, and current static water level, from each well. A 1½-inch Grundfos Redi-Flo submersible pump was used to pump water at D-2 (NGWMN ID 24556) and D-35 (ID 25736). Three volumes of water were successfully removed from D-2 with no observed drawdown in the water level. Black water initially flowed out of the well, but cleared as pumping progressed. D-35, however, failed to yield sufficient water to allow three well volumes to be removed. D-35's casing changes size, to a diameter smaller than the pump, at ~170 feet below the surface. The Grundfos was lowered to this point and pumping began. Black water pumped only a few minutes before stopping. Water level measurements confirmed that the water level had dropped below the pump. IGS staff monitored the water levels for ~15-30 minutes, but did not observe recovery in the water level during that time. IGS staff concluded the well lacked good connection to the aquifer and terminated the pump test.

Airlifting was used to purge water from D-9 (ID 24735), D-11 (ID 25114), D-32 (ID 25593), and D-44 (25941) because of their small casing size. D-32 was the only well from which the IGS airlift equipment successfully purged water. But the airlift at D-32 failed to remove three well volumes. Initially, black water was purged out of the well. During this purge, water was observed coming from two holes in surface casing as well as from the top of the casing. However, water quickly stopped flowing. The airline was lowered several times in an attempt to sustain the airlift. But, an obstruction was hit at ~70 feet below the surface that prevented the airline from being lowered farther. Attempts to remove the obstruction failed and the well did not produce water after that point.

The IGS airlift equipment was found incapable of airlifting water from D-9 and presumably D-11. The static water level in D-9 is ~110 feet below the surface. The equipment used in the initial airlift failed to lift water out of the well due to hydraulic limitations. Based on water left on the airline, the IGS believed the water was ~10-20 feet below the top of the casing. The IGS attempted a 2nd airlift a month later using a larger air compressor. The results were nearly identical as the initial attempt with water reaching was ~10-20 feet below the top of the casing. The static water level in D-11 is ~160 below the surface. The IGS presumed that the same equipment would also have failed to airlift water from D-11 since the static water level is much deeper in it than D-9.

The IGS opted to use a certified well contractor to airlift D-9 and D-11 to ensure water was successfully purged. Wernimont Well (WW) attempted to airlift both wells in December 2021. At D-9, WW was unable to lower the airline below 190 feet below the surface (well depth is 424 feet below the surface). An initial slug of water with clay and sand pieces was all that was purged from the well. WW believes the casing has completely collapsed in the well and the well no longer has connection to the aquifer. At D-11, WW lowered an airline to 300 feet below the surface (well depth is 390 feet below the surface). An initial slug of water was all that purged from the well. Only occasional mists of water were noted during the rest of the hour WW was at the site. WW's opinion is that the well lacked good connection to the aquifer.

Evaluation of the pumping test data indicated that four of the five well in this project lack good connection to the aquifer. Based on a similar situation that occurred at D-24 (ID 25525) the previous year, the IGS believed hydraulic testing at these sites would result in extremely low conductivity values that were not representative of the aquifer and, therefore, were unnecessary. The IGS meet with the USGS NGWMN program coordinator to discuss options. Instead of hydraulic testing the bad wells, a decision was made to continue testing other IGS Dakota wells that are in the network.

D-44 (ID 25941) was not selected for testing in the original proposal. The IGS believed its equipment would be insufficient to purge water in this well because of its small diameter casing (2") and deep static water level, ~220 feet below the surface. The IGS used another certified well contractor, Alton Well Company (AWC), to airlift this well because of these conditions. AWC successfully airlifted the well in February 2022. AWC estimated the well produced 30 gallons per minute for the duration of the 1.5 hour airlift.

HYDRAULIC TESTING

Four of the wells pumped during this project failed to yield water and are believed to lack good connection with the aquifers. Based on a similar situation that occurred at D-24 (ID 25525) the previous year, the IGS believed hydraulic testing at these sites would result in extremely low conductivity values that were not representative of the aquifer. Therefore, the IGS only conducted hydraulic testing on wells that had good connection to the aquifer.

Mechanical slug tests were conducted at D-2 and D-44 sites. The slug tests followed procedures established in the USGS' groundwater technical procedure document 17 (Cunningham and Schalk, 2011). A 1-inch diameter, 2-foot long slug was used at D-2. A ¾-inch diameter, 2-foot long slug was used in D-44. A minimum of four slug tests were conducted at most sites (two slug in and two slug out tests). Additional slug in or slug out tests were conducted at sites if any of the original tests seemed anomalous.

Water levels during the slug tests were collected using a pressure transducer with a built-in data logger (In-Situ Level TROLL 700). The data collection interval varied from 0.5 to 1 second depending on the anticipated response of the aquifer to the slug's introduction and removal. Data from the slug tests was processed in Microsoft Excel and analyzed using the AquiferTest 10.0 software (Waterloo Hydrogeologic). The Hvorslev (1951) methods was used to analyze the slug tests and estimate hydraulic conductivity (K).

Slug test results are presented in Table 1. Hydraulic conductivities varied considerably between wells with average K-value ranging from 33 to 100 feet/day. Unfortunately, no previous estimates of hydraulic conductivity exists to compare the current results. The current results will be used as the baseline to compare future hydraulic conductivities against.

Table 1. Results from slug tests conducted on the NGWMN wells.

Location (NGWMN ID)	Hydraulic Conductivity (feet/day)		Method
	Average	Range	
D-2 (24556)	100	100 to 100	Horslev
D-44 (25941)	33	20 to 40	Horslev

The raw data and analysis results of the slug tests have been entered into IGS Pump Test (https://www.iihr.uiowa.edu/igs/pump-test/) to allow public access. Entries into IGS Pump Test are screened randomly to ensure data standards are maintained.

WEBSERVICE AND DATABASES

The IGS did not encounter any problems with its web services transferring data to the NGWMN data portal in this contract period. No updates to existing web services were completed during the project period.

SUMMARY

The IGS has achieved its project goals. Specifically, the IGS pumped water from six NGWMN wells sites to ensure the wells were still in connection with the aquifer. Mechanical slug tests were conducted at two to establish baseline hydraulic conductivity for future comparison. The raw data and analysis results of the slug tests have been entered into IGS Pump Test for public access. This award has shown, unfortunately, that many IGS Dakota wells lack good connection to the aquifer and need replacement.

References

Cunningham, W.L., and Schalk, C.W., comps., 2011, Groundwater Technical Procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods 1–A1, 151 p.

Hvorslev, M. J., 1951, Time Lag and Soil Permeability in Ground-Water Observations, Vicksburg, MS: U.S. Army Waterways Experiment Station.

APPENDIX A
DETAILED WELL INFORMATION

NGWMN ID	Name	County	Latitude	Longitude	Accuracy	Drill Date	Well Depth	Aquifer
24556	D-2	Plymouth	42.880340	-96.213970	GPS +/- 10 m.	7/1/1977	360	Cretaceous (Dakota)
24735	D-9	Ida	42.518370	-95.641810	GPS +/- 10 m.	11/1/1977	424	Cretaceous (Dakota)
25114	D-11	Cherokee	42.692130	-95.801390	GPS +/- 10 m.	4/14/1978	390	Cretaceous (Dakota)
25593	D-32	Woodbury	42.504090	-96.063870	GPS +/- 10 m.	10/1/1979	221	Cretaceous (Dakota)
25736	D-35	Plymouth	42.809710	-96.547200	GPS +/- 10 m.	11/1/1979	581	Cretaceous (Dakota)
25941	D-44	Sioux	43.152650	-96.058940	GPS +/- 10 m.	7/17/1980	682	Cretaceous (Dakota)