Iowa GS FY2023 NGWMN Project

Final Report
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Award Number G23AC00302
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INTRODUCTION

The National Ground-Water Monitoring Network (NGWMN) provides a unique opportunity to collect and share water-level and water-quality data from different states and agencies. The Iowa Geological Survey (IGS) at the University of Iowa joined the NGWMN in 2017. The IGS contributes data from 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 collected to the NGWMN.

The United States Geological Survey (USGS) awarded funding to the IGS to update a webservice, hydraulically test nine wells, create two wellnests, and install pressure transducers to collect water levels in wells through cooperative agreement G23AC00302. This report describes the work performed and results obtained under this award.

Objective 2B: Support persistent data service

The IGS proposed to modify its GeoSam database to store continuous water level data and update its water level webservice to transfer that data to the NGWMN. A new table to store daily average water levels collected by transducers was implemented in the IGS' GeoSam database. The IGS created a WaterML2 webservice (IGS version 3) to provide both manual measurement and transducer collected water level to the USGS. The IGS submitted this webservice to the USGS in November 2024. This webservice became functional and started transferring data to the NGWMN in January 2025.

Objective 4: Site maintenance

The IGS proposed two projects under this objective: 1) conduct pumping and hydraulic testing on nine wells (figure 1); and 2) make modifications to an existing NGMWN well to only monitor the Silurian aquifer (figure 2).

1) Pumping and Hydraulic Testing

The IGS contracted Gingerich Well Company to pump Oakdale-Sil (NGWMN ID 30000) and Oakdale-Dev (ID 30500) because the water level depth in both wells exceeded the limits of IGS equipment. Pumping occurred in December 2023. Oakdale-Sil was pumped until three well-volumes of water were removed. Oakdale-Dev pumped dry with an initial pumping rate of 20 gallons per minute (GPM). The water level in the well was allowed time to recover. The pumping rate was lowered to ~12 GPM for the second pumping attempt, but the well pumped dry again. The water level in the well was again allowed time to recover. The pumping rate was lowered to ~8 GPM for the third attempt, but the well pumped dry again. The IGS stopped pumping the well at this point.

The IGS' 3-inch submersible pump was utilized to pump Ely NW (ID 23766), Marion (ID 23785), and White Oak Cr. (ID 23891). Pumping occurred in October 2024. All wells were pumped until three well volumes of water had been removed. The amount of drawdown observed in each well was variable. Marion displayed essentially no drawdown, whereas White Oak Cr. had approximately 20' of drawdown before the water level stabilized.

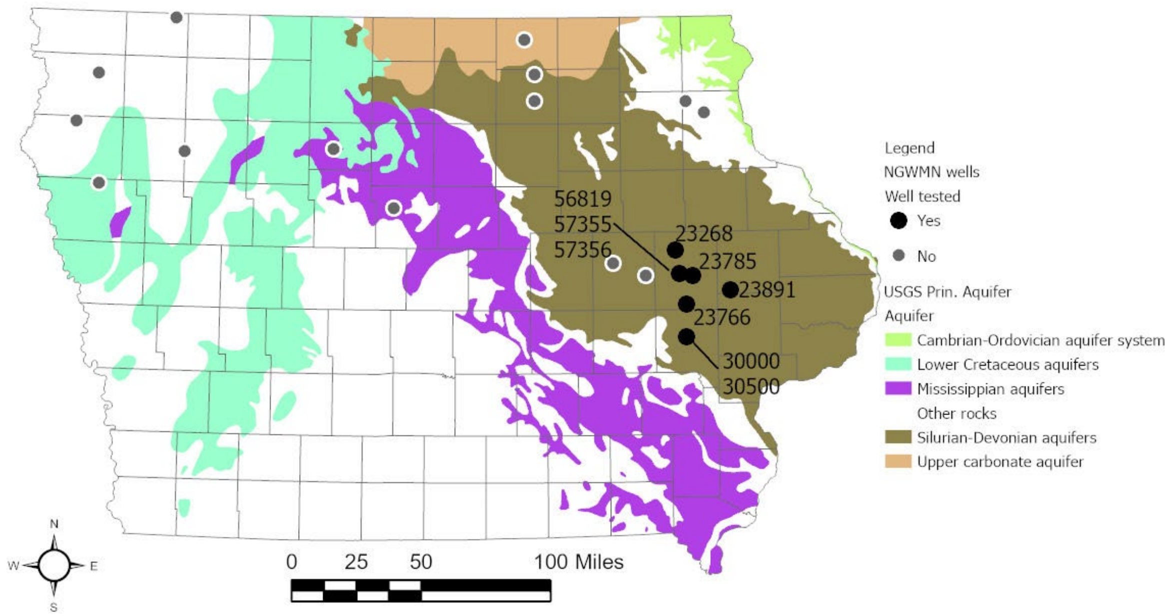


Figure 1. Location of wells selected for pumping and hydraulic testing.

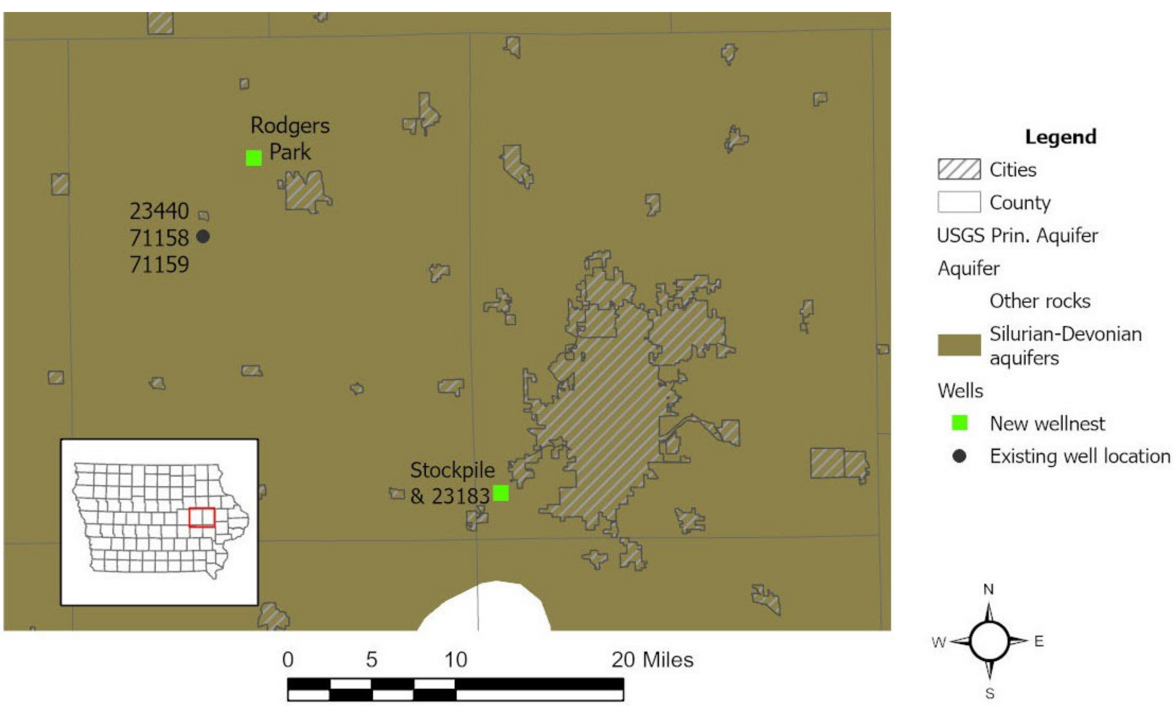


Figure 2. Locations of new IGS wellnests consisting of a Devonian and Silurian monitoring well. IDs and location of the wells replaced with the new wellnests are shown for reference.

The IGS' 1½-inch Grundfos Redi-Flo submersible pump was utilized to pump the remaining four wells. NGWMN ID 57356, has a history of pumping dry. This well was pumped dry and the water level was allowed to recover for ~30 minutes before pumping the well dry again. The remaining wells were pumped until three well volumes of water had been removed.

Aquifer recovery tests were attempted at Marion and Ely NW. However, insignificant drawdowns in both wells prevented recovery tests from being conducted in those wells.

Aquifer recovery tests were conducted on Oakdale-Sil (ID 30000) and Oakdale-Dev (ID 30500). The aquifer recovery tests will follow standard procedures. The static water level for each well was measured with an e-line. An In-Situ Level TROLL 700 pressure transducer was installed in each well and collected continuous at water level data at 1 second intervals. Water levels collection stopped in Oakdale-Sil when the water level recovered to the original static water level and in Oakdale-Dev after 35 minutes of recovery when the rate of water level recovery significantly slowed. Data from the aquifer recovery tests was processed in Microsoft Excel and analyzed using the AquiferTest 10.0 software (Waterloo Hydrogeologic) using the Theis Recovery method (Theis, 1935).

Mechanical slug tests were conducted on the remaining wells. The slug tests followed procedures established in the USGS' groundwater technical procedure document (GWPD) 17 (Cunningham and Schalk, 2011). A 4-inch diameter, 4-foot-long slug was used in Ely NW (ID 23766), Marion (ID 23785), and White Oak Cr. (ID 23891). A 2.5-inch diameter, 3.5-foot long slug was used in the remaining wells. A minimum of four slug tests were conducted at each site (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 five seconds 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). Two separate test methods were used to analyze the slug tests and determine hydraulic conductivity (K): Hvorslev (1951) and Bulter et al. (2003). The Hvorslev method was used in wells where the water level response to the introduction/removal of the slug had minimal oscillations. The Butler method was used in wells where the water level response to the introduction/removal of the slug showed oscillations.

Slug test results are presented in Table 1. Hydraulic conductivities varied considerably between wells with average K-value ranging from 0.2 to 967 feet/day. Slug tests were conducted in several well in 2018. Appendix A compares the results of the 2024 slugs test to the 2018 slug tests. The IGS believes no significant degradation has occurred in the wells because the hydraulic conductivities have similar magnitudes, thus indicating stable hydraulic performance.

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

Site (NGWMN ID)	Hydraulic Conductivity (ft/day)		Method
	Average	Range	
Alice (23268)	0.1	0.1 to 0.2	Horslev
Ely NW (23766)	48	42 to 54	Butler
Marion (23785)	42	31 to 50	Butler
ODW#1 (30000)	0.5		Theis recovery
ODW#2 (30500)	0.1		Theis recovery
Rodgers Park-Dev (101268)	0.1	0.1 to 0.1	Horslev
Rodgers Park-Sil (101267)	3.9	2.8 to 5.2	Horslev
Stockpile- Dev (101037)	0.4	0.2 to 0.7	Horslev
Stockpile-Sil (101036)	2.1	1.7 to 3.0	Horslev
Westfield #1 (56819)	345	280 to 470	Butler
Westfield #2 (57355)	838	760 to 1,000	Butler
Westfield #3 (57356)	14	10 to 19	Horslev
White Oak (23891)	0.9	0.6 to 1.3	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.

2) Well modification

Stockpile (NGWMN ID 23183) was constructed to permit water access from both the Silurian and Devonian aquifers. The IGS contracted Gingerich Well Company to modify the existing well to only open the Silurian aquifer. The modifications were made in accordance with Iowa nonpublic water supply well standards, which are detailed in Iowa Administrative Code [567], Chapter 49 (https://www.legis.iowa.gov/docs/ACO/chapter/10-19-2011.567.49.pdf) and used standard well construction materials.

The initial design called for solid 2 inch PVC casing to be installed and grouted to a depth of 280 feet, just below the Devonian/Silurian contact, and perforated 2 inch PVC casing to be installed from 280-560 feet to allow water into the casing. An obstruction in the original well prevented casing from being lowered deeper than 345 feet. Consequently, the design was modified. The completed well consists of solid 2” PVC casing installed from 0-305 feet and perforated 2” PVC casing from 305-345 feet. Packers were placed on the casing from 282-286 feet. The initial attempt to grout the casing failed. A void near the packers may have allowed the grout to migrate and fill a portion of the well. Holeplug was used to fill this void and grout the bottom of the casing. Cement was used to grout the remainder of the casing to the surface. The well was completed on 10/16/2023. The IGS measured the total depth at 373 feet. Grout from the initial grout attempt may contribute to the change in the total depth of the well. Well construction details are found in Appendix B. A well construction diagram is shown in Appendix C.

An aquifer recovery tested was initially planned upon the well completion. However, the 2-inch casing is smaller in diameter than the smallest IGS pump. Water was purged from the well while Gingerich Well developed the well.

Mechanical slug tests were conducted to establish a baseline hydraulic conductivity for the well. The slug tests followed procedures established in the USGS' groundwater technical procedure document (GWPD) 17 (Cunningham and Schalk, 2011) and used a 0.75-inch diameter, 2-foot long slug. Two slug in and two slug out tests were conducted.

Water levels during the slug tests were collected using a pressure transducer with a built-in data logger (In-Situ Level TROLL 700) that collected measurements at one second intervals. Data from the slug tests was processed in Microsoft Excel and analyzed using the AquiferTest 10.0 software (Waterloo Hydrogeologic). The data was analyzed with the Hvorslev (1951) method to determine the hydraulic conductivity (K). The results are presented in Table 1.

Information for the well is available on IGS' GeoSam database and the NGWMN Data Portal (NGWMN ID 101036). The well was added to the Well Registry, populated with all required elements. Triggers in GeoSam, the IGS' well database, were enabled that allow IGS web services to transfer the well's construction and water-level measurements data to the NGWMN. 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.

Objective 5: Well Drilling

The IGS proposed to drill three new wells in the Silurian and Devonian aquifers. These wells and the well modification in objective 4 create two new wellnests that allow the IGS to monitor the Silurian and Devonian aquifer discretely.

The IGS obtained permission from the Iowa Dept. of Transportation to drill a new well the right-of-way near the original "Stockpile" well and from Benton County Conservation to drill two new wells to replace wells in the Garrison wellnest (NWGMN IDs 23440, 71158, and 71159) at Rodgers Park. Rodgers Park is ~5.5 miles northeast of the Garrison wellnest (figure 2) and was expected to have similar geology as the Garrison wellnest.

The IGS contracted with Gingerich Well Company, an Iowa Department. of Natural Resources Certified Well Contractor, to construct the well to Iowa nonpublic water supply well standards, which are detailed in Iowa Administrative Code [567], Chapter 49 (https://www.legis.iowa.gov/docs/ACO/chapter/10-19-2011.567.49.pdf). Rotary drilling methods and standard materials (ex. PVC casing) were used to construct the well. A locking, protective casing was placed around each well to prevent unauthorized access.

"Stockpile-Dev" (ID 101037) was completed on 10/25/2023; "Rodgers Park-Sil" (ID 101267) on 2/28/2024; and "Rodgers Park-Dev" (ID 101268) on 2/29/2024. Well construction details are found in Appendix B. Well construction diagrams are shown in Appendix C.

The IGS' 1½-inch Grundfos Redi-Flo submersible pump was utilized to pump all wells. Rodgers Park-Sil was pumped until three well volumes of water had been removed and had very little drawdown. The lack of drawdown prevented an aquifer recovery test from being completed. The other wells experienced significant drawdown and water levels reached the pump. The water levels were allowed a ~30-minute period to recover. The wells were then pumped dry again. The IGS discontinued pumping at this point. The slow water level recovery made an aquifer recovery test impractical.

Mechanical slug tests were conducted to establish baseline hydraulic conductivity for each well. The slug tests followed procedures established in the USGS' groundwater technical procedure document (GWPD) 17 (Cunningham and Schalk, 2011) and used a 2.5-inch diameter, 3.5-foot long slug. A minimum of four slug tests were conducted at each site (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 one to five seconds 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 data was analyzed with the Hvorslev (1951) method to determine the hydraulic conductivity (K). The results are presented in Table 1.

Information for the new wells is available on IGS databases and the NGWMN Data Portal. The wells were added to the Well Registry, populated with all required elements. Triggers in GeoSam, the IGS' well database, were enabled that allow IGS web services to transfer the well's construction and water-level measurements data to the NGWMN. 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 databases are screened randomly to ensure data standards are maintained.

The IGS is currently monitoring all wells in the Garrison well nest and the two new wells at Rodgers Park to establish a correlation between the water levels at these sites.

The IGS currently deploys In-Situ Level TROLL 700 data loggers and vented cables of standard lengths to its wells. In-Situ Level TROLL 700s and vented cables, therefore, were purchased and deployed to the sites in October 2024. The Rodger Park wells use 100-foot cables to place the transducer below the static water-level; a 150-foot cable was used at Stockpile-Dev.

Transducer operation follows procedures established in GWPD 16 of the USGS' Groundwater Technical Procedures of the U.S. Geological Survey (Cunningham and Schalk, 2011). Water level data from both sites were downloaded on quarterly site visits. To maintain quality control, transducer readings were checked against manual static water-level measurements and the transducers were recalibrated on these quarterly visits.

The average daily water level collected with the transducers is shared with the NGWMN using the web service created in Objective 2.

Objective 6: Purchase equipment to support continuous water level data collection
The IGS proposed to purchase and install a pressure transducer in Rodgers Park-Sil (the well created under objective 4). An In-Situ Level TROLL 700 and a 150-foot long vented cable was purchased and deployed to the site in October 2024. The transducer at this site operates the same as those described under objective 5.

WEBSERVICE AND DATABASES

The IGS did not encounter any problems with its web services transferring data to the NGWMN Data Portal during the contract period of this award. The water level web service was updated to the WaterML2 standard and incorporates both discrete and continuous water level measurement as part of objective 2 during the project period.

SUMMARY

The IGS has achieved its project goals. Specifically, the IGS updated its water level webservice to WaterML2 standards (objective 2B), pumped and hydraulically tested nine wells (objective 4), created two wellnests by modifying and existing well and drilling three new wells to better monitor the Silurian and Devonian aquifers (objectives #4 and #5), and installed pressure transducers to collect water levels in wells in the new wellnests (objective #5 and #6). These activities improved data transfer to the NGWMN, verified nine wells are still good connection with their aquifers, and improve water level monitoring in the Silurian and Devonian aquifers.

References

Butler Jr, J. J., Garnett, E. J., and Healey, J. M., 2003, Analysis of Slug Tests in Formations of High Hydraulic Conductivity, Groundwater, 41(5), 620-631.

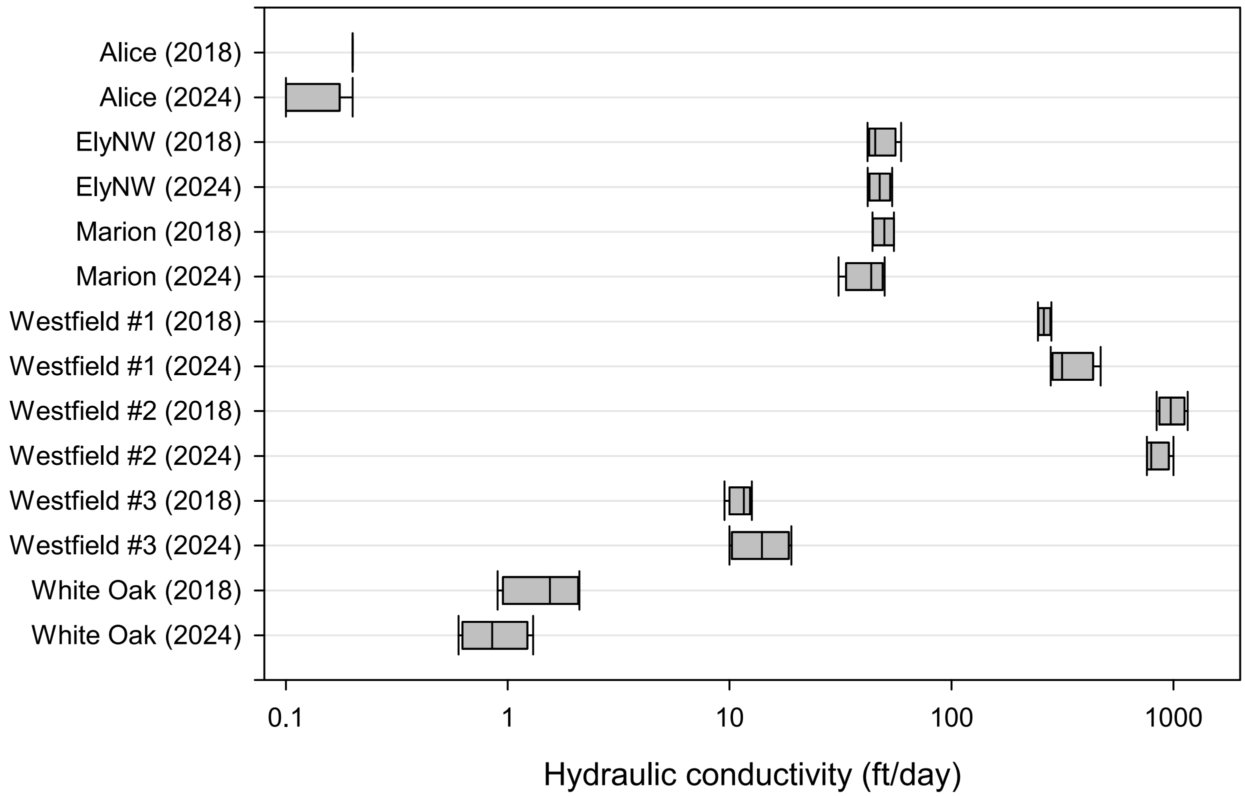
Cunningham, W.L., and Schalk, C.W., comps., 2011, Groundwater Technical Procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods 1–A1, 151 p.

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

Theis, C. V. (1935), The relation between the lowering of the Piezometric surface and the rate and duration of discharge of a well using ground-water storage, Eos Trans. AGU, 16(2), 519–524, doi:10.1029/TR016i002p00519.

APPENDIX A

HYDRAULIC CONDUCTIVY COMPARISON


Alice (2018)
Alice (2024)
ElyNW (2018)
ElyNW (2024)
Marion (2018)
Marion (2024)
Westfield #1 (2018)
Westfield #1 (2024)
Westfield #2 (2018)
Westfield #2 (2024)
Westfield #3 (2018)
Westfield #3 (2024)
White Oak (2018)
White Oak (2024)
0.1
1
10
100
1000
Hydraulic conductivity (ft/day)

APPENDIX B

DETAILED WELL INFORMATION

Name	**NGWMN ID**	**County**	**Replaces NGWMN ID**	**Drill Date**	**Well Depth**	**Prinicipal Aquifer**
Rodgers Park-Dev	101268	Benton	23440	2/29/2024	155	Devonian
Rodgers Park-Sil	101267	Benton	71158 & 71159	2/28/2024	375	Silurian
Stockpile-Dev	101037	Linn	-	10/25/2023	200	Devonian
Stockpile-Sil	101036	Linn	23183	10/16/2023	373	Silurian

Name	GeoSam Link
Rodgers Park-Dev	https://www.iihr.uiowa.edu/igs/geosam/well/101268/general-information
Rodgers Park-Sil	https://www.iihr.uiowa.edu/igs/geosam/well/101267/general-information
Stockpile-Dev	https://www.iihr.uiowa.edu/igs/geosam/well/101037/general-information
Stockpile-Sil	https://www.iihr.uiowa.edu/igs/geosam/well/101036/general-information

APPENDIX C

WELL CONSTRUCTION DIAGRAMS

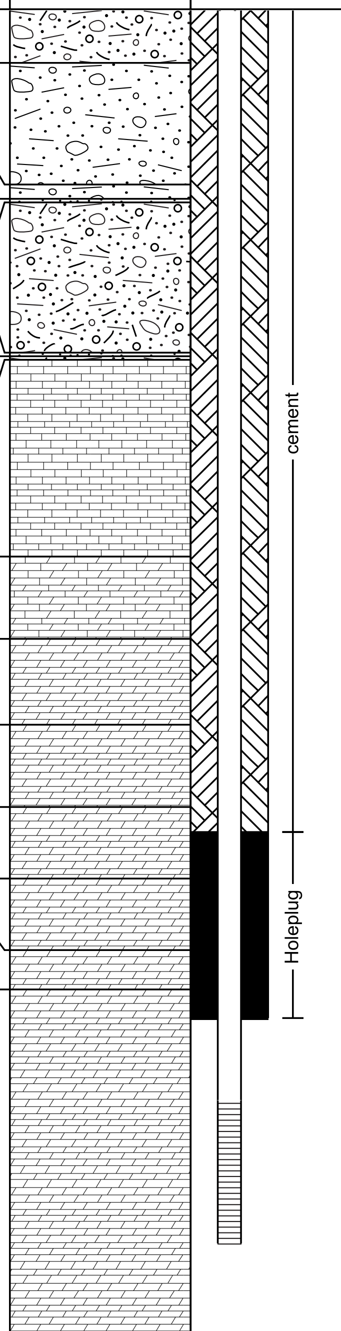
IOWA

GROUNDWATER LOG Stockpile-Sil (ID 101036)

PROJECT NUMBER	**DRILLING DATE** 10/16/2023	**COORDINATES** 41.901831, -91.802555
PROJECT NAME	**TOTAL DEPTH** 373	**COORD SYS** WGS84
		COMPLETION 10/16/2023
		SURFACE ELEVATION 842

COMMENTS	**LOGGED BY**
	CHECKED BY

Depth (ft)	Material Description	Graphic Log	Well Diagram	Elevation (ft)
	Quaternary - clay, yellow			840
20	Quaternary - clay, gray			820
40				800
	Quaternary - clay, brown			
	Quaternary - sand and gravel			
60	Quaternary - till, gray			780
80				760
	Quaternary - sand			
100	Quaternary - till, gray			740
	Devonian (Cedar Valley) - limestone			
120				720
140				700
160	Devonian (Wapsipinicon Formation; Davenport member.) - limestone and dolomite			680
180	Devonian (Wapsipinicon Formation; Spring Grove member) - dolomite			660
200	Devonian (Wapsipinicon Formation; Kenwood member) - dolomite			640
220	Devonian (Otis Formation; Cedar Rapids member) - dolomite			620
240	Devonian (Otis Formation; Coggon member) - dolomite			600
260	Devonian (Wapsipinicon; Betram Formation) - dolomite			580
280	Silurian - dolomite			560
300				540
320				520
340				500
360				480
380	Termination Depth at 373 ft.			460



GROUNDWATER LOG Stockpile-Dev (ID 101037)

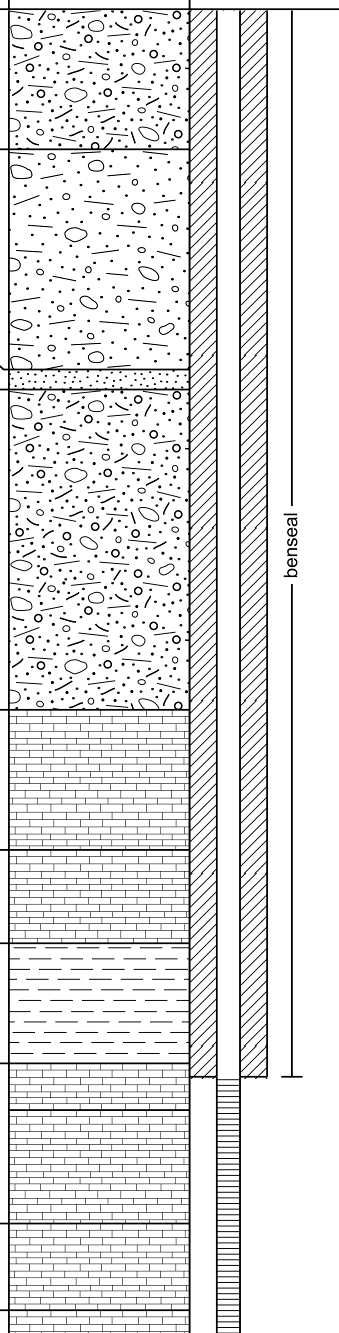
IOWA

PROJECT NUMBER	**DRILLING DATE** 10/25/2023	**COORDINATES** 41.901882, -91.802430
PROJECT NAME	**TOTAL DEPTH** 200	**COORD SYS** WGS84
		COMPLETION 10/25/2023
		SURFACE ELEVATION 845

COMMENTS	**LOGGED BY**
	CHECKED BY

Depth (ft)	Material Description	Elevation (ft)
	Quaternary - clay, yellow	840
10		830
20	Quaternary - clay, gray	820
30		810
40		800
50	Quaternary - sand, gray	790
60	Quaternary - clay, gray	780
70		770
80		760
90		750
100		740
110	Devonian - limestone, brown	730
120		720
130	Devonian - limestone, gray	710
140	Devonian - shale, gray	700
150		690
160	Devonian - limestone, gray	680
170		670
180		660
190	Devonian - limestone, tan	650
	Devonian - limestone, brown	
200	Termination Depth at 200 ft.	640

Graphic Log / Well Diagram



GROUNDWATER LOG Rodgers Park-Sil (ID 101267)

PROJECT NUMBER
PROJECT NAME

DRILLING DATE 02/28/2024
TOTAL DEPTH 375

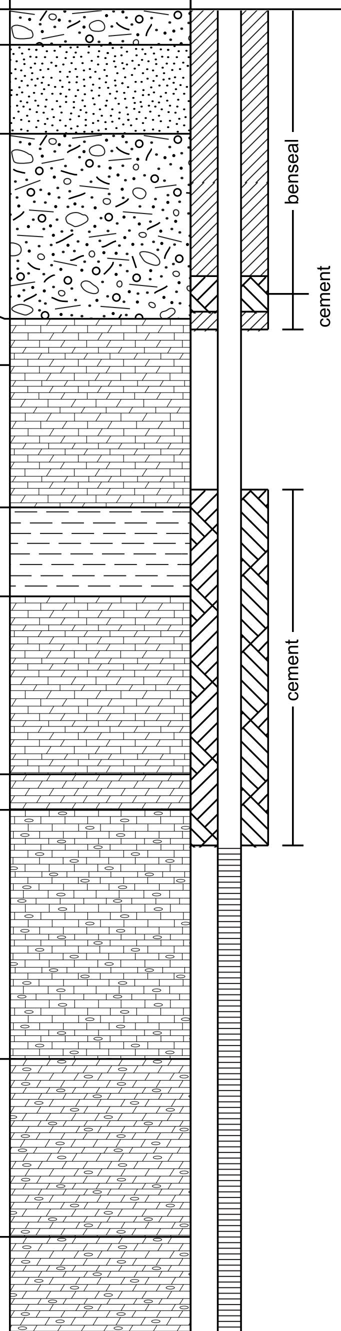
COORDINATES 42.192931, -92.084285
COORD SYS WGS84
COMPLETION 02/28/2024
SURFACE ELEVATION 845

COMMENTS

LOGGED BY
CHECKED BY

Depth (ft)	Material Description	Elevation (ft)
	Quaternary - clay, yellow	840
20	Quaternary - sand, yellow	820
40, 60, 80	Quaternary - clay, gray	800, 780, 760
	Devonian (Little Cedar Fm.) - limestone, gray->tan	
100, 120	Devonian (Pinicon Ridge Fm.) - limestone and dolomite	740, 720
140, 160	Devonian (Pinicon Ridge Fm. - Kenwood member) - shale	700, 680
180, 200	Devonian (Otis) - limestone and dolomite	660, 640
220	Devonian (Bertram Fm.) - dolomite	620
240, 260, 280	Silurian (Laporte City Fm.) - limestone and chert	600, 580, 560
300, 320, 340	Silurian (Hopkinton Fm.) - dolomite and chert	540, 520, 500
360	Silurian (Blanding Fm.) - dolomite and chert	480
380	Termination Depth at 375 ft.	460

Graphic Log / Well Diagram



Disclaimer This bore log is intended for environmental not geotechnical purposes.

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GROUNDWATER LOG Rodgers Park-Dev (ID 101268)

PROJECT NUMBER	**DRILLING DATE** 02/29/2024	**COORDINATES** 42.192946, -92.084224
PROJECT NAME	**TOTAL DEPTH** 155	**COORD SYS** WGS84
		COMPLETION 02/29/2024
		SURFACE ELEVATION 845

COMMENTS	**LOGGED BY**
	CHECKED BY

Depth (ft)	Material Description	Graphic Log	Well Diagram	Elevation (ft)
	Quaternary - clay, yellow			840
10	Quaternary - sand, yellow			830
20				820
30	Quaternary - clay, gray			810
40				800
50				790
60				780
70				770
80				760
90	Devonian (Little Cedar Fm.) - limestone, gray->tan			750
100	Devonian (Pinicon Ridge Fm.) - limestone and dolomite			740
110				730
120				720
130				710
140				700
150	Devonian (Pinicon Ridge Fm. - Kenwood member) - shale			690
160	Termination Depth at 155 ft.