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Final Technical Report

Project Title:

Updating and Expanding IGWS Contributions to the NGWMN

Agency Name:

Indiana Geological and Water Survey

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Objectives:

2A. Support persistent data service from existing data providers

5. Well drilling

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Overview

The Indiana Geological and Water Survey (IGWS) became a new data provider to the USGS National Ground-Water Monitoring Network (NGWMN) under the FY2016 NGWMN program announcement with agreement dates from 9/1/2016 to 8/31/2018 (Grant/Cooperative Agreement No. G16AC00360). The work completed under this agreement is the seventh award under the NGWMN program for an existing data provider. This report completes the work required under the FY2023 NGWMN Grant/Cooperative Agreement No. G23AC00300, (with agreement dates 9/1/2023 to 8/31/2025.)

Former grant awards funded efforts to compile and organize data into NGWMN formats from an existing micrometeorological and groundwater monitoring network, the Indiana Water Balance Network (IWBN). The IWBN website is https://legacy.igws.indiana.edu/iwbn-dashboard/#/. New monitoring wells often complement micrometeorological networks or may be stand-alone groundwater monitoring locations. Data contributed from the IWBN to the NGWMN can be found at https://cida.usgs.gov/ngwmn/.

The goal of the IWBN and its network of monitoring wells is to gather representative monitoring of environmental activities that measure the inflow, flux, and outflow of water within various systems (atmosphere, soil, and aquifer). Developing flow paths that define the movement through the hydrosphere within a variety of physiographic settings helps to characterize the variations seen within these systems. By including the collection of groundwater and aquifer data at multiple depths, the dynamics of the groundwater system can be assessed. This can be a mutually beneficial effort, as it can also support the desired data collection efforts for the NGWMN. As we evaluate the groundwater in the state, we are poised to find wells that can support a national- and regional-scale data set for the assessment of important aquifers in Indiana. Our shared goals are to assess the baseline conditions and long-term trends in water levels in these aquifers and to continue to drive data collection. To that end, our monitoring network is expanding and has been redesigned to assess the best aquifers. With the wells selected and drilled with this round of funding, our network has grown to 23 wells (3 original replacement wells still available) that represent USGS principal aquifers of alluvial and glacial origin, Mississippian aquifers, and secondary hydrogeologic regions of other aquifers.

NGWMN program Objective 2 (support persistent data service from an existing data provider), utilizing Part A (update sites and information to keep NGWMN data current and ensure accuracy), was completed during this two-year project. We reviewed network site data to determine missing components and to analyze the proper method for updating the site numbers in the data tables. While reviewing the network data many of the datums were updated to match the datum being used, from GRS 1980 to NAVD88. This was accomplished in January 2024. Additionally, some well depths were updated and changed from meters to feet in the registry. Other aquifer data were verified and corrected when necessary. Lastly, efforts were made to correct well screen information and lithology when more accurate or supplemental information was available. A consistent numbering scheme for site numbers was created and site numbers were updated in the NGWMN Monitoring Location Registry when the new geodatabase was put online. Site identification numbers include a two-digit county code followed by a two-digit year the well was drilled or put into service, and then a two-digit sequential number. With the implementation of the geodatabase in 2023, we were able to update the site numbers in the data tables and NGWMN registry while providing the geodatabase within the XML web service.

Other tasks included updating site classifications in accordance with the Tip Sheet on Minimum Data Requirements for Candidate Sites, the NGWMN Framework Document (ACWI, 2013), and the NGWMN Data Portal and Data Provider pages. The minimum data elements were populated in the geodatabase and services connected while ensuring the new connections were stable and flowing. Web service connections to the portal were maintained during the transition and fixed when incorrect data or missing links were found. Monthly checks were made of data fetches on the NGWMN data provider dashboard, and the NGWMN was contacted to resolve issues on seven occasions. These resulted from such challenges as the transition to our new geodatabase, mapping changes within the host links, the portal going offline momentarily, or bugs in the NGWMN Data Portal URL system when it was upgraded to its permanent location. All problems were resolved.

NGWMN program Objective 5 (well drilling) was completed during the project period. The goal of adding three wells to the network to improve the spatial distribution of monitoring wells in USGS principal aquifers has been successful. We have increased the number of monitoring wells within the Mississippian and in sand and gravel aquifers to align with the number suggested in the NGWMN Tip Sheet on Well Selection Criteria for Water Levels. Pressure transducers have been installed at four new wells to initiate monitoring. A fourth well also included in the network is discussed below.

Well with site ID 282302 (Bloomfield_N) was drilled with the intention to screen in the Mississippian bedrock system. However, no aquifer was encountered during drilling within the Mississippian system, so instead of wasting the time and money on the drilling efforts, a well was screened in the Pennsylvanian bedrock. However, we were able to install a well at site ID 602501 Freedom_E, which is monitoring the Mississippian aquifer system.

Initially, the planned Owen County well was chosen to use an existing borehole in McCormick's Creek State Park that was in a water-bearing Mississippian formation. This well could not be installed, however, due to borehole complications that led to the collapse of the well. Instead, we were able to retrofit an existing water well east of Freedom, Ind., as a replacement to target the Mississippian Principal Aquifer. This well has been given site ID 602501 and named Freedom_E.

Instead of one replacement well for site ID 021604 (FortWayne_N2), there are now two new wells. The primary well was drilled to capitalize on drilling already being conducted by our glacial geologists; it was given site ID 172404 (Ashley_W). Additionally, a nearby well that is owned by ACRES Land Trust and with a conservation easement overseen by DNR allowed us to convert the old water well onsite into a monitoring well; it was given site ID 022403 (FortWayne_N4).These two wells represent sand and gravel principal aquifers and have similar lithology and water-level trends to site ID 021604 (FortWayne_N2) well.

Support the NGWMN as a data provider

The goal of supporting persistent data services and timely uploads has been completed per Objective 2. Quality assurance and quality control procedures are performed for NGWMN wells at least triennially and are updated in the water level files. A uniform spatial database engine (SDE) houses the NGWMN data and feeds it into the NGWMN data portal.

The NGWMN Monitoring Location Registry now contains consistent site numbering which includes a two-digit state designated county code, a two-digit year the well was drilled or put into service, and then a two-digit sequential number. All site numbers were made consistent and updated within the registry and across all associated data tables in early winter 2023. The new wells, Bloomfield_N (Site ID 282302), Ashley_W (Site ID 172404), Freedom_E (Site ID 602501) and FortWayne_N4 (Site ID 022403), have been added to the registry per Objective 5 and comply with the updated site numbering scheme.

Network support process

Through the last grant cycle (G22AC00135), the data structure that supports the IGWS-maintained groundwater monitoring network was transformed into a unified geodatabase (SDE) to streamline workflows and increase efficiency to deliver data to NGWMN. Since then, bugs have been worked on to enable smooth delivery of data to the NGWMN portal. Some challenges still exist with the data pull from our hourly data collection to serve the daily data preferred by NGWMN. We have been working through the quality assurance quality control (QAQC) processing steps to try to automate this process. We are working to build in a standardized output time stamp that is compatible with NGMWN; however, we are still having challenges with this process and for the time being, we are relying on manual collection, processing, and delivery of this data.

With the changeover to the SDE in the fall of 2023, all data was reviewed and updated to ensure accuracy in locations, depths, lithology, and other minimum data elements. All new wells and associated data collected were entered into the SDE as of the fall of 2025. Location data was collected using the Trimble DA2 GPS Catalyst in conjunction with ArcGIS Field Maps. Then, elevation data was compiled using Indiana's 2016–2020 hydro-flattened bare-earth Digital Elevation Model (DEM) from IndianaMap. This data is derived from statewide QL2 Light Detection and Ranging (LiDAR) airplane imaging and follows USGS 3DEP standards. These standards were included in the registry for the new wells put into the system.

Spatial feature classes (point and polygon) in ArcGIS Pro are used for relevant spatial data such as well locations. Non-spatial tables are populated using SQL Server Management Studio (SSMS) or ArcGIS Pro. NGWMN schema view tables are populated in SSMS or in ArcGIS Pro. The geodatabase published in ArcGIS Enterprise is authorized to the Web Feature Service (WFS) for reporting to NGWMN.

Water level data for the NGWMN is now being supplied in feet to comply with the NGWMN standards in the new SDE. Values are being quality-checked for significant figures and standards to be served to the NGWMN portal.

Lithological data was updated to include gamma-log interpretations along with the existing core description from the borehole. The "Lithology" table updated during the rebuild is now associated with the pattern numbers set forth in the FGDC Digital Cartographic Standard for Geologic Map Symbolization associated with the lithological patterns using Section 37.1 – Sedimentary-rock lithologic patterns. This data structure allows us to better develop cross sections of the lithology associated with wells.

All new wells were inventoried for well pop-up heights, casing diameters, and verified screen lengths from well drilling records to ensure that casing and screen data were correct.

Data collection methods

Manual water level measurements

IWBN sites are visited, on average, every quarter (3 months) to conduct maintenance and collect manual and automated water-level data. Manual measurements of groundwater level and total well depth are made from the well reference point, typically the top of the well casing marked by an indelible marker, using a Geotech ET electronic-tape meter (accuracy = +0.01 ft). The measurement, date, and time are recorded in field sheets, and well sediment accumulation is noted, if present. Measurements are transferred to a well metadata spreadsheet when field personnel return to the office. Field sheets are scanned into PDF format and saved to a network directory to provide paper and electronic versions of field notes.

Automated water-level measurements

Continuous groundwater-level data are collected using vented (e.g., Druck PDCR series or Campbell Scientific CS451 sensors) and non-vented (e.g., In-Situ Rugged Troll) pressure transducers. The IGWS is working toward using vented instruments as the standard automated measurement approach, which would also facilitate real-time data service; however, the transition is constrained due to budget limitations, including the need for multiplexers to expand to the required number of IWBN site datalogger terminals.

Monitoring wells instrumented with non-vented (i.e., absolute) pressure transducers with internal memory are downloaded immediately after manual water-level measurements are taken, during routine site visits. Barometric pressure sensors at the site are also downloaded; raw water-level data are compensated for barometric effects using sensor manufacturer software. The uncorrected water-level, barometric, and compensated water-level data are stored on a field laptop hard drive and then transferred to a network directory upon field personnel’s return to the office.

Description of data quality and quality assurance protocols

The quality assurance and quality control (QA/QC) protocol establishes the required quality standards and outlines the methods to maintain this quality throughout the project’s deliverables and research processes. Following the guidelines of the NGWMN Framework Document (ACWI, 2013), continuous water-level data are calibrated using manual measurements. Water-level data are logged hourly or on minute timescales using non-vented or vented pressure transducers. Non-vented pressure transducers are downloaded in the field manually to a mobile device during site visits. Vented pressure transducer data can be downloaded directly from the datalogger source in the field or remotely using a modem. Manual depth-to-water measurements are taken during each field visit. Non-vented pressure transducer groundwater data are barometrically compensated using site-specific barometric pressure data that are logged at the same time of the submerged pressure transducer. The compensated water-level data, reported as water column depth (i.e., the height above the pressure transducer) or as depth to water, are recorded in an Excel worksheet alongside manual measurements that are synchronized to the nearest time stamp. To convert manual depth-to-water readings to groundwater elevations, the well casing stick-up height is subtracted from the depth-to-water measurement, and this value is added to the ground elevation determined by digital elevation modeling (DEM) at the well point. All well measurements are recorded and analyzed in feet.

The manual water elevation measurements (y-axis) are plotted against compensated water column measurements or depth to water from the sensor (x-axis) on a scatter plot (**fig. 1**). A linear trend line is applied, with a linear coefficient (R^2) greater than 0.85 required to confirm consistency. The equation generated from this trend line is used to calculate groundwater elevation each hour and takes the compensated height above the pressure transducer or depth to water recorded from the sensor (x), multiples it by the slope (m) generated from the regression relationship, and then adds or subtracts an elevation (b). If the pressure transducer is replaced or repositioned within the well column, a new regression equation is created to recalibrate the system. A hydrograph is plotted with hourly groundwater elevations and periodic manual groundwater elevation measurements to verify that these measurements correspond well with the continuous record by doing a visual QA/QC check.

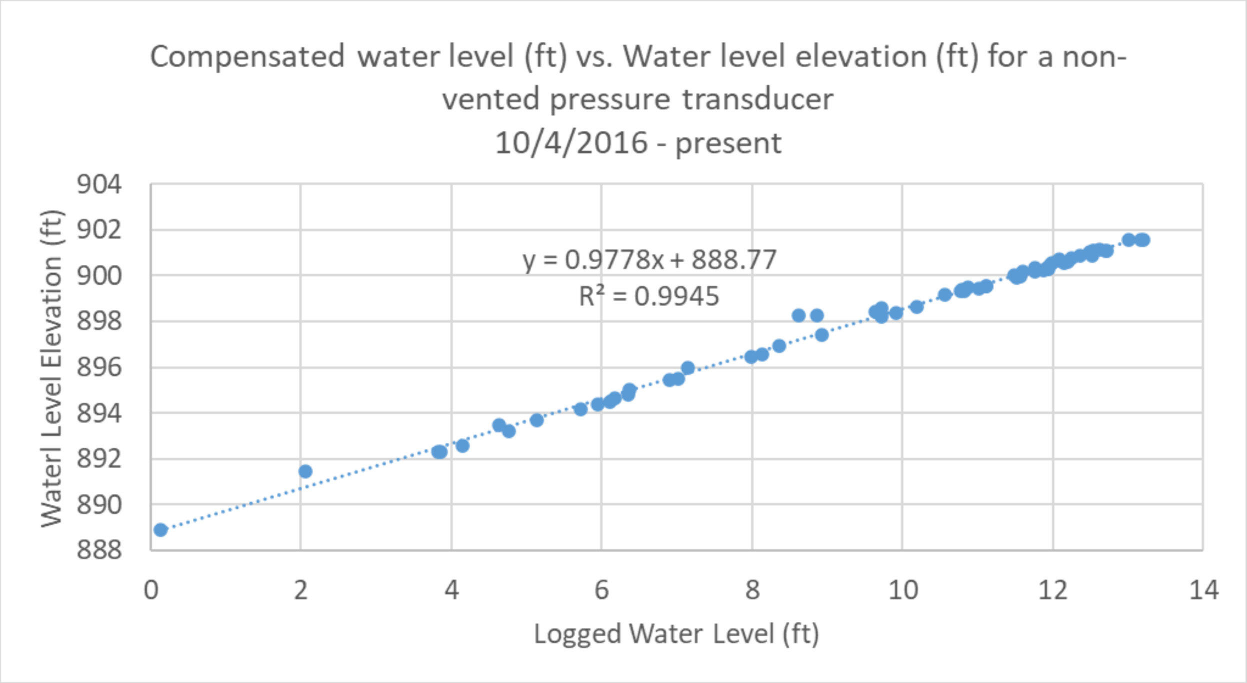

Figure 1. Graph showing the linear regression equation generated from the compensated pressure transducer water column reading and the manual groundwater elevation measurements at the same time. This example is from Brownsburg_N1 (Site ID: 531601).

A standardized data processing routine using spreadsheets to convert data from barometrically compensated non-vented pressure transducers and vented pressure transducers into the NGWMN web service format is still being used while we are updating procedures in the SDE. The NGWMN network requires date and time to be in ISO8601 format. To achieve this, the Excel concatenate function was used to convert the date and time recorded by the pressure transducer (e.g., 8/22/2024 11:30) into the ISO8601 format (e.g., 2024-08-22T11:30:00-05:00). The value "-5:00" indicates the difference from Coordinated Universal Time (UTC), also known as Greenwich Mean Time. An example of the concatenate formula is as follows:

```
=CONCATENATE(TEXT(A8,"yyyy-mm-ddThh:MM:ss"),$J$2)
```

(cell J2 contains the value -5.0)

Accuracy values for pressure transducer measurements were sourced from the manufacturer's technical specification sheets. These accuracy values are expressed as a percentage of the pressure transducer's full scale (FS). By multiplying the accuracy percentage by the FS, the resulting value is entered into the Observation Accuracy field in the WATERLEVEL file that is stored in the SDE that serves to the NGWMN Data Portal.

Corrected depth-to-water measurements are calculated by subtracting the groundwater elevation from the ground elevation. The rounded depth-to-water values are reported to the NGWMN for each hour. In the future, the process of QA/QC and water-level elevation computation will likely be done automatically using Python scripting to create accurate water-level data that are free from human error.

Well drilling activities

With funding from this grant, two wells were drilled and two additional wells were repurposed into monitoring wells from their former use as domestic supply wells. This is a bonus of one well from what was proposed. Both Bloomfield_N and Ashley_W were drilled for Objective 5; the other two new wells to the network, Freedom_E and FortWayne_N4, were repurposed to monitor water levels in valuable aquifers. Freedom_E repurposed well use came after a collapse of the original proposed Owen County borehole redrill at McCormick’s Creek State Park. The 21 wells in the network, including these four wells, are shown in **Table 1**. A map showing the spatial distribution of NGWMN wells operated by the IGWS, including the four new wells, is shown in **Figure 1**.

Table 1. List of NGWMN wells operated by the IGWS.

Site name	Site ID	Latitude (WGS84)	Longitude (WGS84)	Altitude (ft)	Well depth (ft)	Principal aquifer
Atlanta_S	291913	40.20952	-86.02689	857.1	113.9	Other aquifers
Bloomington_N	531712	39.19399	-86.51311	759	13.4	Mississippian aquifers
Brownsburg_N1	531601	39.89448	-86.37302	912.4	39.3	Other aquifers
FortWayne_N1	021602	41.24759	-85.11812	874.8	100.8	Aquifers of alluvial and glacial origin
FortWayne_N2	021604	41.24772	-85.13912	840.1	79	Aquifers of alluvial and glacial origin

Frankfort_S	122201	40.22712	-86.43012	929.7	365.5	Other aquifers
Glenwood_N	212202	39.63908	-85.29161	1098	60	Other aquifers
Indianapolis_N	491611	39.81836	-86.20442	705.5	6.2	Other aquifers
Jasper_S	192103	38.30611	-86.86852	585.5	55	Other aquifers
LakeStation_W	459701	41.58454	-87.27534	589.8	14.5	Other aquifers
Lebanon_N	062102	40.12625	-86.41975	926.2	213	Other aquifers
Martinsville_N	552101	39.49888	-86.42708	609.4	70	Aquifers of alluvial and glacial origin
Muncie_N	189103	40.22216	-85.42320	938.1	33.1	Other aquifers
Nappanee_NE	201902	41.45389	-85.98386	871.5	157.6	Aquifers of alluvial and glacial origin
NewCastle_NE	330405	40.05339	-85.31495	1008.6	9.6	Other aquifers
Rushville_S	701201	39.57998	-85.46494	944.5	12.3	Aquifers of alluvial and glacial origin
Worthington_N	602301	39.16823	-87.00589	528	41.4	Aquifers of alluvial and glacial origin
Bloomfield_N*	282302	39.08538	-86.91518	649	256.5	Other aquifers
Freedom_E*	602501	39.20497	-86.84477	739.4	245.7	Mississippian aquifers
Fort Wayne_N4-(R)*	022403	41.25879	-85.14291	839.3	78.5	Aquifers of alluvial and glacial origin
Ashley_W*	172404	41.51546	-85.13509	946.6	353	Aquifers of alluvial and glacial origin

*New and replacement wells from this grant cycle

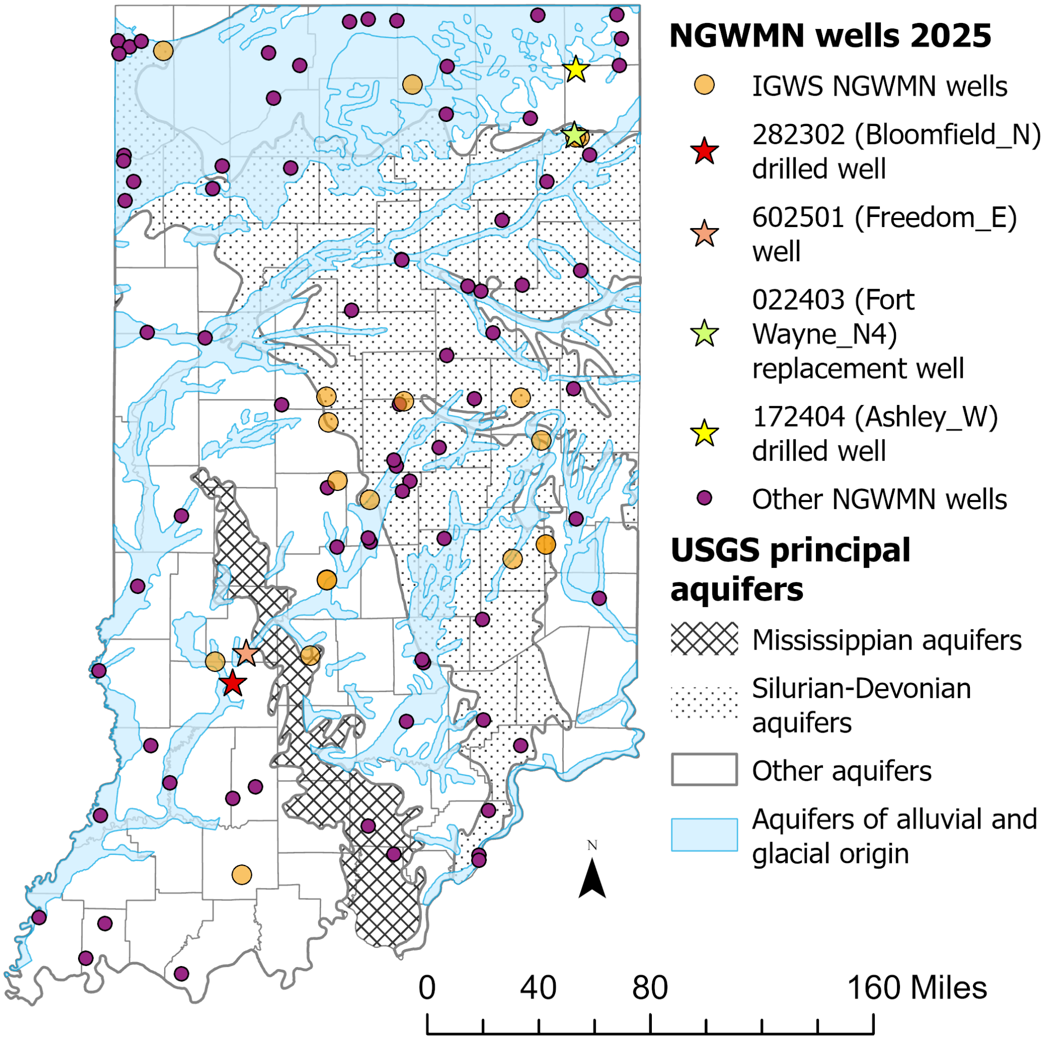

Figure 2. Map of NGWMN sites in Indiana with the stars showing the locations of the new wells. IGWS-operated wells are symbolized with an orange dot and other monitoring wells on the NGWMN are symbolized with a purple dot.

Bloomfield_N

Site reconnaissance, landowner access, and general planning for Bloomfield_N (Task 1, Year 1)

The Bloomfield_N monitoring well (Site ID 282302) was referred to as Greene County Bedrock Well or GCBW in the proposal and will be referred to as Bloomfield_N from this point on. Bloomfield_N was installed to address key water-related questions and to cover groundwater data gaps in Greene County. At the initiation of this project, only two wells in the state represented the Mississippian principal aquifer. Effective monitoring necessitates between three and 10 wells in this aquifer system according to the NGWMN Tip Sheet on Well Selection Criteria for Water Levels. To bring down the cost of deep drilling, drilling efforts were coordinated with the STATEMAP project, which involved drilling and investigating a borehole to determine the contacts between the Stephensport and West Baden Groups in Greene County along with mapping the extent of the great unconformity that lies between the Mississippian strata and overlying Pennsylvanian units. The location of this borehole and these contacts are within the Mississippian principal aquifer, making this collaboration possible. Significant water withdrawals, irrigation wells, and private wells also were mapped in the area to understand the influences on any new wells installed and to understand what overlying aquifers are being used in this area.

After identifying the general proximity of potential sites for filling STATEMAP data gaps that had reduced impacts from nearby wells, we developed a list of parcels that were publicly owned (local, county or state agency), university-owned, or contained in a land trust, easement, or additional non-use covenants. A thorough investigation of potential landowners and properties to approach for partnership for a long-term host of a monitoring well was conducted. We reached out to partners within state agencies, township leadership, local soil and water conservation districts, and others that may assist on the search. One long-standing partner of the IGWS that owns land in the area was Sycamore Land Trust. Sycamore Land Trust and the IGWS have a shared goal of conserving natural resources and stewarding water resources.

The Sycamore Land Trust (SLT) Cookson Preserve north of Bloomfield, Ind., was identified as a prime location for the Bloomfield_N well. The SLT board and leadership required a scientific proposal documenting the scientific purpose, duration, and planned activities on their property and asked us to address specific questions about disturbance of the property. The Research Permission Form, proposal, and permission for use and access forms are provided in **Appendix A**.

A team of IGWS Staff and SLT staff conducted underbrush cleanup on Sept. 25, 2023, to allow drillers access to the planned well location. Utilities and service line companies within the vicinity of the well site were notified by calling 811. We worked with Eastern Heights Water Utility to access water for the drilling crew's use, discuss well placement, and discuss the utility's potential use of the data for influence on their well field aquifer.

To maximize the potential for a productive aquifer, the plan was to use ESRI Collector/Survey 123 field apps to document minimum data elements for the monitoring network. Our GIS technician position became vacant twice during this grant cycle, so an app was created to collect the location of assets within the IWBN network. Additional desktop surveys using GIS data layers were used to fill in remaining data gaps.

Well drilling, development, and geophysical logging for GCBW (Task 3, Year 1)

Drilling was contracted from the Illinois State Geological Survey (ISGS) between October 23 and November 11, 2023. A truck-mounted drill rig using mud rotary drilling methods and wireline coring tools was used to collect continuous soil and bedrock core. A 4-in-diameter borehole is drilled during the core recovery phase. Core was sampled in 10-ft lengths when possible. Full recovery of bedrock was expected. Some problems with drill bits, drilling pressures, and loss of circulation at around 45 ft caused confusion between drilled depth and core recovery amounts that propagated downhole. Instances of pulling out 1.4 feet extra core continued along the hole after a loss of core early on. Cores were discharged from the core barrel onto a half PVC pipe, rinsed to clean off the bentonite drilling mud, and reviewed for a simplified field description. Cores were packed into core boxes and labeled with the site identification number and depths.

Core description

Detailed core descriptions were conducted on Bloomfield_N starting immediately upon return from the field. Bedrock descriptions of both the unconsolidated and bedrock portions were completed using our facilities and photographs; samples and descriptions were logged through the core. However, perceived concerns with depths were noted both in the field notes/drillers' logs and the gamma logs. Some time was taken to collect and analyze additional gamma logs to cross-check results and ensure the core was marked at the correct depths. Finally, we determined that there was about 1.4 foot offset from an early unit that propagated down the core logs. This offset was corrected for the final core description, sample analysis, and aligned with the gamma log. Total recovery was 326.3 ft of core, indicating a loss of 23.5 ft. Of those, 17.8 ft were lost in the unconsolidated material that sat in the first 36 ft of the hole. The remaining 5.7 ft of loss seemed to occur in the coal deposits, unit transitions, or poorly indurated sandstone, making interpretation using gamma counts more straight forward.

The detailed core description and associated gamma log can be found in **Appendix B**. Our bedrock geologist, concluded that we did, in fact, enter the units of the Blue River Group at 326.2 ft of the Upper Mississippian, including the Paoli Limestone which typically is considered part of the principal Mississippian aquifer of the United States described in the Ground Water Atlas of the United States: Segment 10, Illinois, Indiana, Kentucky, Ohio, Tennessee (Lloyd et al., 1995). The groundwater atlas also states that within the Mississippian units, the Reelsville Limestone, Sample Formation, Beaver Bend Limestone and through the Bethel Formation (of the West Baden group) are often considered local limestone and sandstone aquifers of the upper Mississippian. During core description, the transition from the Pennsylvanian bedrock to the Mississippian bedrock was thought to have occurred by the appearance of carbonates in the system. A 1-ft-thick dolostone was the first carbonate appearance at 263.3 ft deep, followed by green shale. This transition marked the unconformity between the Pennsylvanian Racoon Creek Group and the Mississippian West Baden Group. Our bedrock geologists indicated that the transition into the West Baden Group was in the Reelsville Limestone from 262.5 to 263.3 ft at the unconformity, with the overlying Pennsylvanian strata of the Raccoon Creek Group within the Caseyville Formation (previously called the Mansfield Formation). The groundwater atlas notes that the Caseyville Formation generally contains salt water. Fluid conductivity tests along with multi-channel resistivity and specific potential geophysics tests did not show salinity within this unit. We screened the well in this unit, but further investigation would be good to verify with a water quality testing program on this well.

Bedrock cores were described in detail at the IGWS Materials Testing Facility. Color identification and description were determined after wetting the core and using the coding system in Thompson and Keith (2015). Bedrock is described first by the dominant lithology (sandstone, siltstone, shale, etc.), followed by an examination of transition zones between rock units, weathering patterns, grain size, grain shape, grain sorting, bedding, presence of fossils, and organic deposits. Transition zones may exhibit gradual or abrupt contacts, while weathering manifestations can encompass oxidation, reduction (e.g., iron staining), and core condition indicators like fractures and faults. Grain size, shape, and sorting are pivotal in delineating aquifer characteristics and understanding water movement dynamics. Furthermore, bedding, fossils, and organic materials serve as crucial indicators for identifying specific formations and lithologic groups. After description, the stratigraphic column is created using the Windows™.NET program Column (v. 1.02).

Well installation and development for Bloomfield_N

The target aquifer for this well was the Mississippian bedrock; however, due to the lack of aquifer presence in the Mississippian, the well was instead screened in the Pennsylvanian sandstone bedrock of the Caseyville Formation. Our geophysical logs only showed slight indications of water units in the lower units, and the thickness of those units was less than 5 ft. At most, we saw what may have been a saline kick in the fluid conductivity within a shale layer which may have been just interstitial water at 325 ft. The drillers agreed that the lower units did not indicate they were water bearing. Since a suitable aquifer within the Mississippian bedrock was not found, we instead decided, based on the geophysical information and local knowledge, that the overlying sandstone could be monitored as a regional aquifer. We knew from nearby investigations that the Caseyville unit hosts springs. From talking with neighboring well owners and the local water company, it became apparent that this sandstone aquifer may be more productive than previously understood.

The well diagram for Bloomfield_N is shown in **Appendix C**. The diagram includes the first depth-to-water measurement taken. A full-suite geophysical analysis consisting of five-point moving average gamma radiation, fluid conductivity, and temperature probes was run on the open borehole. The stratigraphy between approximately 220 and 264 ft consisted primarily of sandstone from the Pennsylvanian Raccoon Creek Group of the Caseyville Formation. A significant fracture was identified in the core between 246 and 248 ft with iron staining, indicating secondary fluid flow. Based on the quality of the sandstone and fractures, and the increase in conductivity found in the geophysical logging results, it was decided to place the well and screen it between 237 and 252 ft.

After initial drilling, on Nov. 7, 2023, the hole was re-reamed to a 6-inch diameter to the depth of the final monitoring well at 253.5 ft. Cuttings were used to backfill the underlying 4-inch borehole. A 15-ft-length, 2-inch inner diameter, 2 3/8-inch outer diameter screen was installed from 237 to 252 ft below ground surface (bgs). A 1-ft spacer of the same diameter was installed below the screen and attached to the well point to allow for particle collection and capacity and to reduce risk of screen clogging. Casing of the same diameter with a total length of 250 ft was installed above to 34 inches above surface grade. A 36-inch protective pipe was installed with a surface seal of concrete. The total depth of the final monitoring well is 253.5 ft bgs with a total depth from top of casing of 256.5 ft.

Figure 3. Photo of the Bloomfield_N protective cover immediately after installation at SLT Cookson Preserve.

Filter sand pack (No. 5) was installed from the bottom of the well from 253.6 to 235 ft. A 2-ft Bentonite seal of pellets was used over the filter sand. The drillers' tremie pumped 2.38 lbs/gal mud weight bentonite slurry into the annular space from 233 to 2 ft bgs. A concrete seal was placed in the last 2 ft to surface to help anchor the casing and create the surface seal.

The large depth of the well made it hard for the drilling crew to properly develop it. The drilling crew recommended following up with additional development and pumping to properly clean the screen and ensure proper connection to the aquifer. This work will be conducted in the next project budget period.

Gamma logs and other downhole geophysics

Geophysical logs were collected during drilling by the IGWS staff including 8-, 16-, 32- and 64-inch normal resistivity, single-point resistance (SPR), spontaneous potential (SP), natural gamma, borehole temperature and fluid conductivity measurements using the Mount Sopris Scout-PRO Acquisition system. Data collection was done on Nov. 2, 2023, prior to casing the well. The first run was with a full column of all three probes. Upon return it was decided to get a gamma-only run downhole to ensure accuracy in depth measurements because questions about depths of core arose during drilling. We returned on Jan. 18, 2024, to rerun gamma to ensure our measurements and depths of units were accurate.

Gamma counts were used to interpret units when core was missing, not collected, or it was hard to determine its properties. Natural gamma can help to understand the lithologies and clay content of units and is used to interpret lithology when sample is unavailable.

The gamma log showed a decrease in gamma counts around 218 ft deep that continued to about 262 ft deep, associated with a large sandstone unit. An increase in fluid conductivity around 220 ft continued to 260 ft, indicating the potential for water storage and movement. Gamma, fluid conductivity, and temperature results are included with the well diagram in Appendix C.

Portable X-ray fluorescence

Portable X-ray fluorescence (pXRF) uses high-intensity X-ray fluorescence, which detects the amount of light that certain chemicals give off from absorbing radiation, to determine the relative abundance of elements in a core sample. Data from pXRF can be used for 1) chemostratigraphy; 2) understanding subsurface geochemical properties; 3) characterizing subsurface aquifers/aquitards; 4) identifying naturally occurring groundwater trace metal contaminants; and 5) aiding geologists in making inferences on mineralogic change within bedrock core (Zambito and others, 2022). PXRF was completed on the Bloomfield_N core with samples taken every half-ft to ft (**Appendix D**).

Site latitude, longitude, and elevation (GPS positions)

The location of Bloomfield_N was collected using the Trimble DA2 GPS Catalyst in conjunction with ArcGIS Field Maps. Using an RTK fix mode, we mapped this data point at sub-meter horizontal accuracy (0.671 m).

Elevation data was compiled using Indiana's 2016–2020 hydro-flattened bare-earth DEM from IndianaMap. This data is derived from statewide QL2 LiDAR Point Cloud data that follows USGS 3DEP standards. The elevation for Bloomfield_N is 649 ft.

Monitoring and web services for Bloomfield_N and Freedom_E (Task 7)

Monitoring was initiated on Feb. 26, 2024, at Bloomfield_N. The water level data has had abnormal trends. Every time hand measurements were taken, the water level changed in elevation (**Figure 4**). However, hand measurements still matched the sensor and water level data, and temperature behaved consistently. We have contacted In-Situ about this phenomenon, and they determined that the sensor appears to be working correctly. We have attributed this deviation to three possibilities: there is a neighboring well that turns its pump on and off, affecting the water levels at Bloomfield_N (but that doesn't describe why this change occurs at every field visit); or the pressure transducer we installed is a 100 ft (In-Situ RuggedTROLL 100) and not the usual 30 ft we usually deploy, and it is possible that the transducer is getting stuck in the well column, or the string experiences extension over time, after deployment, due to the significant depth at 129.5 feet below ground surface . We recently have noticed that the line seems to stick to the casing site upon redeployment. We have 3D-printed centralizers and are trying gaskets and other tools to see if this solves the problem.

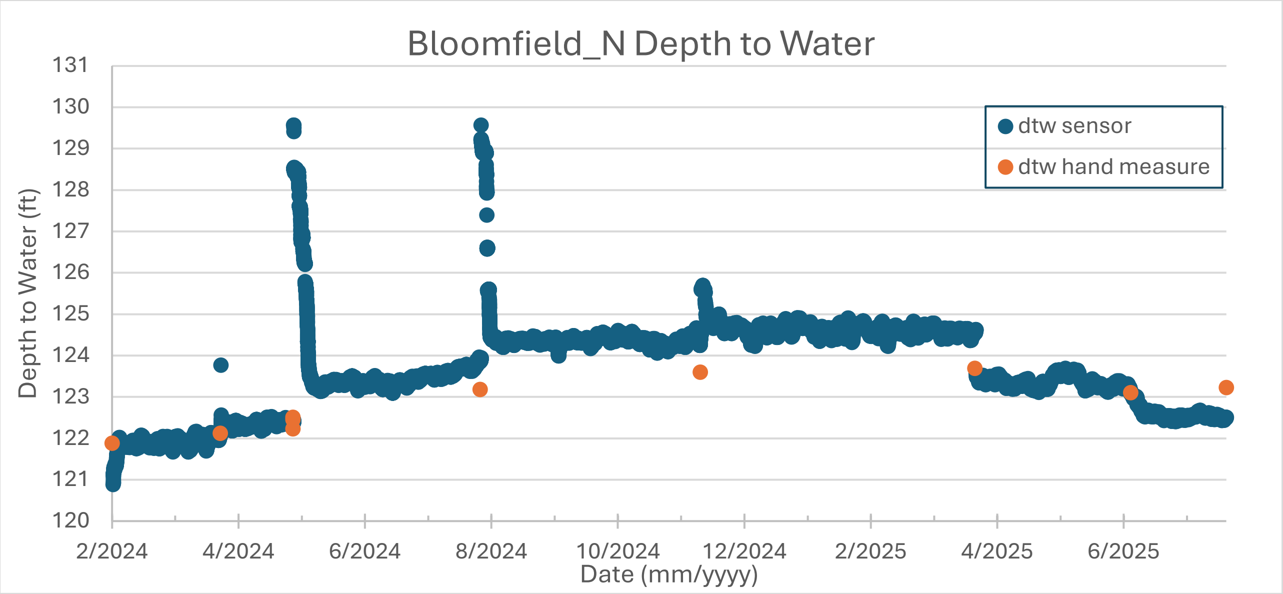

Figure 4. Graph showing the Bloomfield_N water level and temperature trends.

Freedom_N

Site reconnaissance, landowner access, and geophysical logging for the Owen County well (Task 2, Year 1)

The plan to install an Owen County well at McCormick's Creek State Park failed due to the borehole collapse. Our team had exhausted all resources trying to find a driller willing to re-ream the hole and place a casing and screen in the borehole drilled in 2023-2024. We contacted the Indiana Department of Natural Resources (DNR), Division of Water (DOW) to discuss options. Mark Basch, section head of the Water Rights and Use Section at DNR DOW, suggested we could place a liner in the existing borehole after using bentonite to fill the portion of the hole that would be unused. We explored the well with our geophysical equipment and previously collected downhole video to determine the planned depth of screen, backfill and well construction. We identified bedding planes and fractures that appeared to be water bearing and were targeted for screen placement. We worked over 4 consecutive weeks on projects to log the hole, survey the site for elevations, construct the protective cover, dig out existing popup to resecure, and construct the liner for this well. After pouring bentonite into the well to obtain the desired screening depth of 171 ft, severe rain and excess runoff ultimately caused the collapse of the borehole. We secured the cap 3 ft below grade, backfilled the hole with cement and soil, and sealed the hole with additional bentonite. Cardwell of the USGS told the IGWS team on May 20, 2025, that we could evaluate and rehabilitate a nearby well in the same hydrologic formation, if possible.

The IGWS Water Team researched possible unused wells in the Owen County, Ind., area that were in Mississippian bedrock. Our team reached out to BBP Water Corporation serving the Town of Spencer and parts of rural Owen County, the soil and water conservation district (SWCD), local land trusts, and even personnel at the local schools looking for well owners seeking to cap, plug or abandon an unused water well. On June 2, 2025, a suitable replacement well was found on the property of Owen County Soil and Water Conservation District Board Member Gary “Steve” Fox’s property. A total of three wells in the Owen County area were visited and assessed for water level and usability; the third well examined was chosen as a replacement for the collapsed borehole due to its depth, relative geologic location, and accessibility. **Appendix E** shows the site permission use and access form for this location. This well had been buried and capped with a secure cover; during the summer of 2025, the landowner and IGWS interns excavated it and assessed its condition. This well contained a ~ 200-ft pump that was removed on June 9, 2025, by IGWS staff and the landowner in order to access and well to measure and monitor. A downhole geophysical examination, depth-to-water, and total depth measurements were completed June 9, 2025. We started monitoring this well right away and instrumented it on Aug. 19, 2025, to ensure it could be used as a functional groundwater monitoring site.

A gamma log was run at the Freedom_E well on June 9, 2025. The results were coupled with nearby DNR well records (DNR RefNo 224164) and compared to core descriptions from the Fox property, Bloomfield_N core, and McCormick’s Creek boreholes to correlate geology. The Fox property core (SDH 529), collected near Arney, Ind., sits 6.2 miles northwest of the Freedom_E well site and shows Raccoon Creek lithology associated with Pennsylvanian stratigraphy. The McCormick’s Creek borehole (SDH480) sits 8.9 miles northeast of the Freedom_E well and shows middle Mississippian units of Blue River Group as the first unit. The Bloomfield_N well is 9 miles southwest and has similar mixed units as the Freedom_E lithology described in the nearby well log. The Freedom _E well likely contains the units associated with the West Baden group but also shows indications of the overlying Stephensport Group which consists of about equal parts limestone, shale, and cliff-forming sandstone. The Freedom_E well gamma log at an elevation of 717 ft above sea level was compared to the nearby DNR well (RefNo: 224164), which was field-located at 707 ft above sea level. Since the proximity of this well was within

1,000 ft of the monitoring well and offset by only 10 ft, the lithological description of the units from this well log was used. Based on its location and the aquifer system associated with it, we place the well in the top of the Mississippian unit associated with the Stephensport Group and the water-bearing formation within the West Baden Group. The well diagram for Freedom_E is shown in **Appendix F** along with the first depth-to-water measurement, gamma radiation log, and electrical resistivity for the N64 channel run on the cased borehole. The lithology and lithological description interpreted from gamma and described in the nearby well log are also included.

Well construction and development for the Owen County well (Freedom_E) (Task 4, Year 1 occurred in Year 2)

Water level and depth tests were conducted at the new Freedom_E well on July 8, 2025. The first depth to water was at 199.5 ft below the top of the excavated well casing and a total depth from that same point was 248.4 ft. Upon inspection we determined that the steel casing had a PVC liner install within it at some point in the past. It was capped with a steel bolted cap and buried below grade. We approximated that the well sat 33.5 inches below the ground surface. A protective well cover and casing had to be brought above ground level for ease of access, to protect against contamination, and to bring it up to state well construction standards. The liner within the well was loose and unstable along with it being 34-inches below ground surface. To rectify this a 4-inch PVC extension was coupled to the existing 4-inch PVC in the well. We extended the 5-ft diameter steel protective cover above grade by joining the existing original steel casing with a coupler. A 5-gallon bucket was used as a concrete form positioned over the coupler and the steel casing and bottom of the protective cover. The 5-gallon bucket was positioned and then filled bentonite pellets first then covered with a bag of concrete provide a sturdy seal encasing the two components. Unfortunately, upon a subsequent site visit we found that the PVC coupler to the liner did not hold due to the instability of the liner. To further secure, we placed a spacer grommet just above the joint on the new extension of PVC to stabilize the well between the liner and the protective pipe. This immobilized the casing within the protective pipe. To provide additional stability, a reverse coupler was placed between the PVC and the protective cover and pushed into the existing liner. After the rebuild, water level tests were performed and read at 204.2 ft for depth to water and 252.8 ft for total depth or 251.2 ft bgs on July 9th. The hole around the well was backfilled with the soil previously dug out from around it. The steel casing is now 36 inches above ground surface and the PVC casing is 1.6 ft above ground surface. A notch and caret were placed on the casing for consistent depth measurements.

Figure 5. Photos documenting the Freedom_E well rehab and construction process.

The InSitu barometer (SN-1142418) was initiated on Aug. 15, 2025, but we had to return the first pressure transducer to the company because it would not connect to the communication device. The non-vented pressure transducer (SN-1240176) was initiated on Aug. 19, 2025, with the first depth-to-water measurement corresponding to the installation of the pressure transducer at 205.7 ft from the top of the casing. Minimum data elements were collected including popup height, casing diameter, latitude and longitude string length, and other parameters needed to conduct quality control procedures.

FortWayne_N2 Replacement Wells: Ashley_W and FortWayne_N4

Site reconnaissance, landowner access, and general planning for Ashley_W and FortWayne_N4 (Task 5, Year 2)

The FortWayne_N2 monitoring well (Site ID 021604) is being threatened by site development. Landowners have been willing to delay development of the property for a few years while we tried to find a suitable replacement and created side-by-side water level collections to determine whether the replacement well is truly monitoring the same aquifer. After conducting a geological assessment of the area using Flemming (1994), the goal of the replacement well is for it to be located within the Eel River Paleo Meltwater Channel deposition associated with the Huntertown Formation, which is characterized by thick deposits of sand and gravel. The FortWayne_N1 (Site ID 021101) is within the more recent alluvium and more directly influenced by Cedar Creek than FortWayne_N2.

We reached out to ACRES Land Trust to discuss the ability to redrill this well in the adjacent Bicentennial Woods. Unfortunately, the property was inaccessible due to a state-held conservation easement which would not allow for temporary roads or clearing for access. They encouraged us to look at other nearby ACRES properties to assess the ability to capture this aquifer elsewhere. Due to our existing wells across Cedar Creek and on the north side of the Cedar Creek Canyon (glacial landform) and the difference in reaction to the surface installation, we started to reach out to other landowners in the area west of Cedar Creek Canyon in the Huntertown interlobate morainal region. At the same time, we were also working with our glacial geologists to assess other sites

Since a drilling campaign was underway in this area through our Great Lakes Geologic Mapping Coalition partnership, it made sense to pursue a collaborative approach   Another well 18.5 miles north (Ashley_W) was drilled in partnership with our glacial geologists in November 2024 to try and find a replacement well in the alluvial and glacial aquifers of NW Indiana. If we determine that there is a connection between these wells, with the nearby concerns over the Michindoh aquifer use which spans the states of Michigan, Indiana, and Ohio, we thought this would be a valuable well for replacement. While planning and reconnaissance were being conducted for Ashley_W, a contract for services was set with the Illinois Geological Survey to conduct the drilling in this area. Site selection started with contacting the DNR to determine if boat ramps would be a suitable location for a monitoring well. Story Lake public access site was selected as the most convenient for both parties. We conducted several site visits to select a location, work with neighboring landowners, and find a potable drilling water source. On Oct. 21, 2024, we obtained the cooperative agreement and permission for use and access form which can be seen in **Appendix G**. Ultimately, no well was placed in this area.

Around the same time, a suitable site closer to FortWayne_N2 was suggested; it was an orphaned well on an ACRES Land Trust property, Little Cedar Creek Wildlife Sanctuary. An initial site visit conducted Aug. 28, 2024, determined that a pump was still in this well and water level, depth, and other information was unknown until the pump could be pulled. We worked out an agreement with ACRES land trust that allowed us to pay for and pull the well; if well was not suitable and could not be rehabilitated for monitoring purposes, they would then take steps to seal and cap it to protect groundwater resources. The proposal for the project is included in **Appendix H**.

After the pump was pulled and the well was assessed, we determined that this well would be a good fit as a replacement well for FortWayne_N2. This well, effectively named FortWayne_N4 (Site ID 022403), became the replacement. Paperwork and permission were given by ACRES and DNR, and these agreements are in **Appendix I**.

Well drilling, development, and geophysical logging for Fort Wayne replacement wells (Task 6, Year 2)

Drilling was contracted from the Illinois State Geological Survey (ISGS) for Ashley_W. A truck-mounted drill rig using mud rotary drilling methods and wireline coring tools was used to collect continuous soil, unconsolidated sediments, and bedrock core. A 4-inch-diameter borehole was drilled during the core recovery phase and core was sampled in 10-ft lengths when possible.

Cores were discharged from the core barrel onto a half PVC pipe, rinsed to clean off the bentonite drilling mud, reviewed for a simplified field description, and packed into wax-lined core boxes. Core boxes were labeled with the site identification number and core depths. Coarse-grained samples from intervals of poor recovery were collected from the mud circulation pit in a food strainer and rinsed of bentonite drilling mud and collected in sample bags. Samples and core were wrapped in plastic if poorly indurated to be brought to the laboratory for full description.

Drilling was done by the Illinois State Geological Survey (ISGS) between Nov. 4 and Nov. 14, 2024, using the mud rotary drilling and wireline sampling method.

For FortWayne_N4 we contacted several licensed well drillers in the area and found Hollenbaugh Well Drilling was willing to attempt pulling the well. They warned us that often, wells were encrusted, and if they could not successfully pull the well, the well would need to be abandoned. The proposal with Acres Land Trust and IDNR (**Appendix H**) was accepted to turn the orphaned well into a monitoring well after the old pump was removed and it was determined that the screen was still in good condition and in contact with the aquifer. On Oct. 17, 2024, we met Mike and Greg Hollenbaugh at the well site and the pump was successfully removed. Measurements of the well and aquifer were conducted immediately after. The well is 75.37 ft deep and has a steel casing with inner diameter of 4 inches and outer diameter of 4.5 inches.

A solid slug test was performed using a 5-ft slug with a 1.75-inch diameter on FortWayne_N4 to assess the connection to the aquifer and the quality of the well. The results are shown in **Figure 6** for a slug-in test and a slug-out test. During the slug-in portion, water levels rose to static conditions within 1 minute, ensuring a good aquifer connection. The slug was taken out 5 minutes after the end of the test and water levels also rose to static conditions within a minute of removing the slug.

A pressure transducer was added to the new well to initiate monitoring and compare the water levels to FortWayne_N2 (old) and FortWayne_N1 (**Figure 7**). The patterns for groundwater levels from FortWayne_N2 (old) and FortWayne_N4 are the same, but the old well has higher groundwater elevations than the new well. All three wells share a connection to the aquifer.

A gamma and resistivity geophysical analysis was conducted on FortWayne_N4 to determine the screen interval and create a hypothesized geologic column. The well diagram, gamma and resistivity testing results, and an estimated stratigraphic column are shown in **Appendix J**. FortWayne_N4 used the nearby FortWayne_N2 lithological description and gamma interpretation.

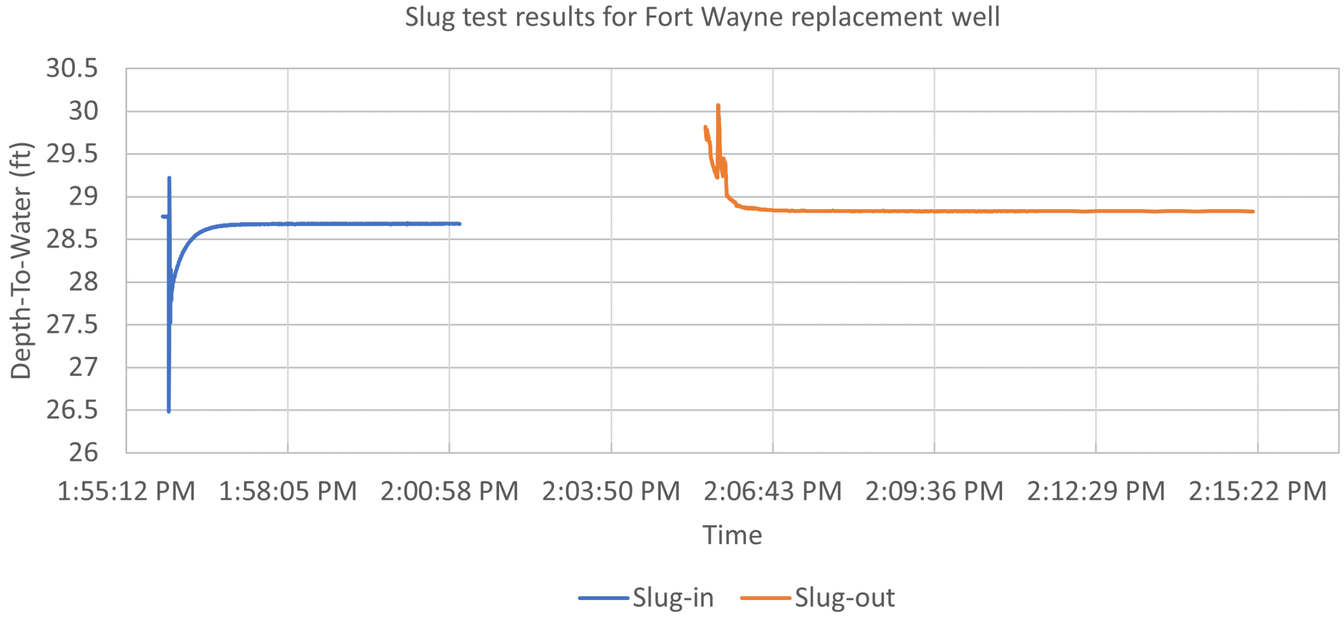

Figure 6. Graph showing results for the slug-in and slug-out test for FortWayne_N4. Water levels rapidly returned to stagnant water level conditions, indicating that the well has a good connection to the aquifer.

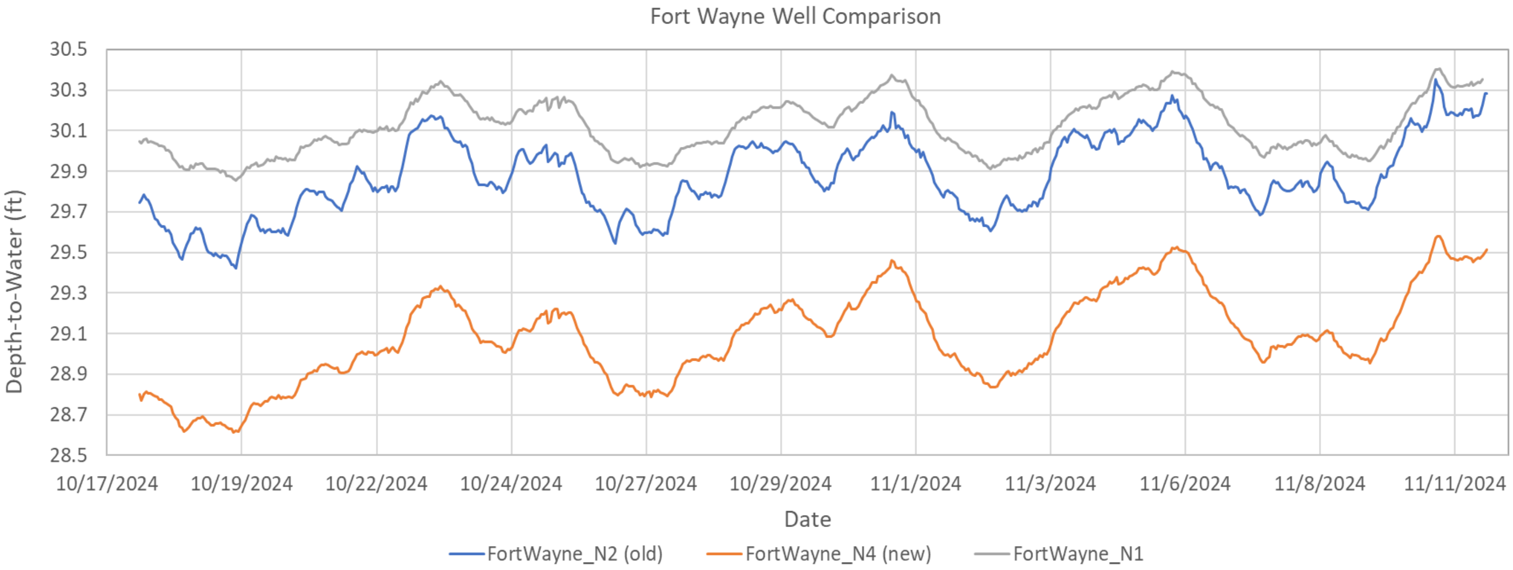

Figure 7. Graph showing depth-to-water-level comparisons of the new FortWayne_N4 (orange line) water levels compared to FortWayne_N1 (gray line) and FortWayne_N2 (blue line) water levels.

Poor recovery of the Ashley_W core was obtained. A total of 42 ft was recovered of the 390 ft of drilled depth. Much of this was due to the sand and gravel nature of the hole; with heaving sands, large gravel clasts that were easily pushed and displaced during drilling caused binding and other problems, so we had to rely on other evidence for descriptions. Field notes were made using drill accounts, recovered core, grab samples, and the gamma log. Unconsolidated core descriptions and grain-size sample collections were conducted at the IGWS sediment laboratory. The description for the unconsolidated deposits includes the U.S. Department of Agriculture (USDA) texture with additional description for pebbles greater than 2 mm, Munsell color, hydrochloric acid reaction, lithologic code, and any miscellaneous features. Lithologic codes are based on Eyles and others (1983). The codes of F for fines (silt/clay), S for sand, G for gravel, and SG for sand and gravel are based on standard lithostratigraphic units for describing unconsolidated deposits. D for diamicton is a poorly sorted mixture of clay, silt, sand, and gravel, up to boulder sizes. Tills are a common type of diamicton assumed to have been deposited from melting glacial ice. The detailed descriptions of the unconsolidated units were recorded using a Microsoft Access database form referred to informally as Core-nucopia. **Figure 8** shows the lithological association made from this hole to the Great Lakes Geologic Mapping Coalition report and **Appendix K** shows the full lithological description and gamma interpretations made from field notes and samples.

After initial drilling, on Nov. 14, 2024, the hole was re-reamed to a 6-inch diameter to the depth of the final monitoring well at 250.5 ft. Cuttings were used to backfill the underlying 4-inch borehole from 390 ft to 253 ft. A 10-ft-length, 2-inch inner diameter, 2 3/8-inch outer diameter screen was installed from 240 to 250 ft below ground surface (bgs). A well point was installed below the screen as the base of the well. Casing of the same diameter with a total length of 243 ft was installed above to 36 inches above surface grade. A 42-inch protective pipe was installed with a surface seal of concrete. The total depth of the final monitoring well is 253.3 ft bgs with a total depth from top of casing of 256.3 ft.

Filter sand pack (No. 5) was installed from the bottom of the well from 253 to 238 ft. A 2-ft Bentonite seal of pellets was used over the filter sand. The drillers' tremie pumped 1 lbs/gal mud weight bentonite slurry into the annular space from 236 to 2 ft bgs. A concrete seal was placed in the last 2 ft to surface to help anchor the casing and create the surface seal.

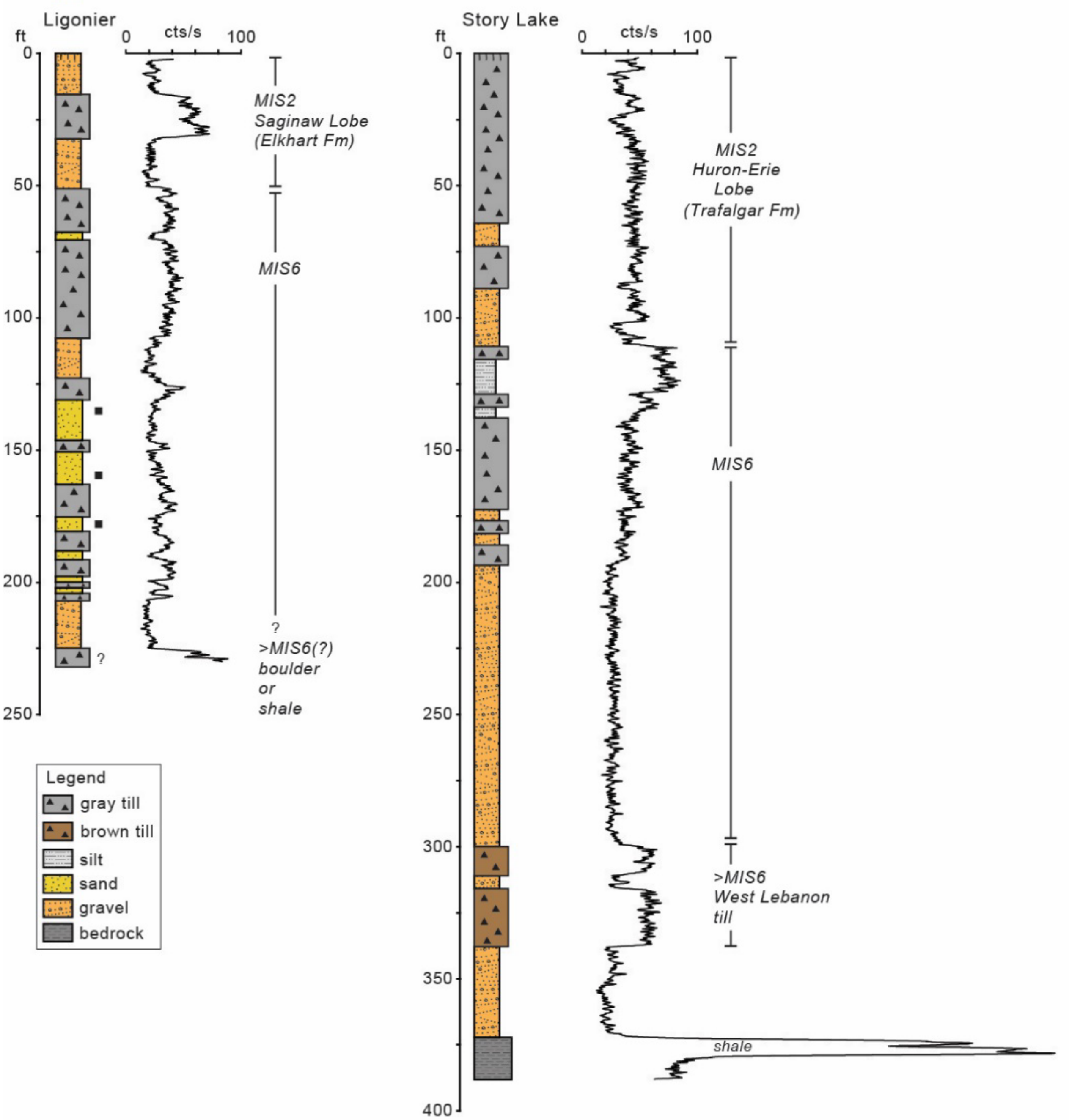

Figure 8. Stratigraphic log, downhole gamma-ray log, and interpreted age/unit for the Ligonier and Story Lake (Ashley_W) cores collected as part of the Great Lakes Geologic Mapping Coalition partnership.

Initiate monitoring and transfer web services for the Fort Wayne replacement wells (Task 8, Year 2)

Monitoring for FortWayne_N4 started on Oct. 17, 2024, with the placement of pressure transducers in the well. As shown above, the water levels for FortWayne_N4 closely follow the water level trends in the old FortWayne_N2, indicating that these two wells are screened in the same aquifer, just at different distances to Cedar Creek. Water level data are shown in **Figure 7** for FortWayne_N4.

Monitoring for Ashley_W started Nov. 14, 2024, and water levels, temperatures, and hand measurements are shown in **Figure 9**. The water levels from the pressure transducers have had QAQC procedures completed on them by using three hand measurements by the processes described above. Seasonal water trends are visible, with an increase in groundwater during the springtime and drought conditions in the late summer and fall.

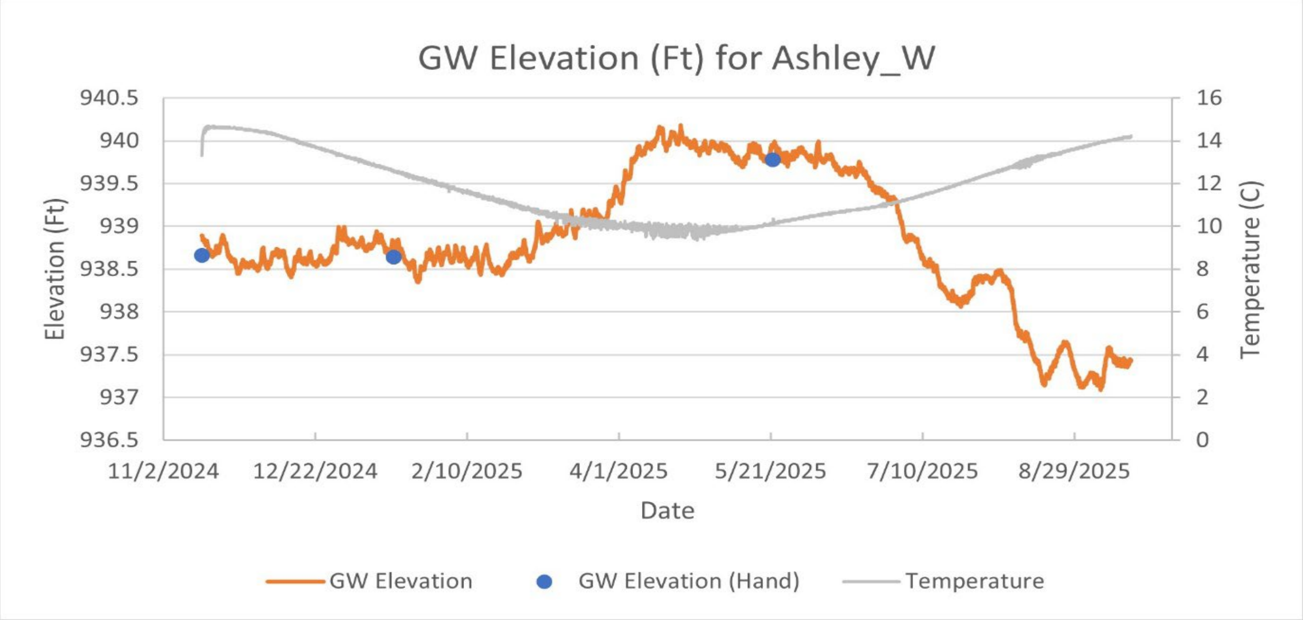

Figure 9. Ashley_W water level and temperature trends. The orange line shows water levels taken from the sensor and have had QAQC run using three hand measurements (blue dots). The light gray line is the temperature taken from the sensor.

References

Brown, S. E., Fleming, A. H., Jones, H., and Schrader, T. L., 1998, Glacial terrains of the Mongo, Wolcottville, and the Indiana part of the Burr Oak 7.5-minute quadrangles, LaGrange and Noble Counties, Indiana: Indiana Geological Survey Open-File Study 98-06, 24 p. https://hdl.handle.net/2022/28875

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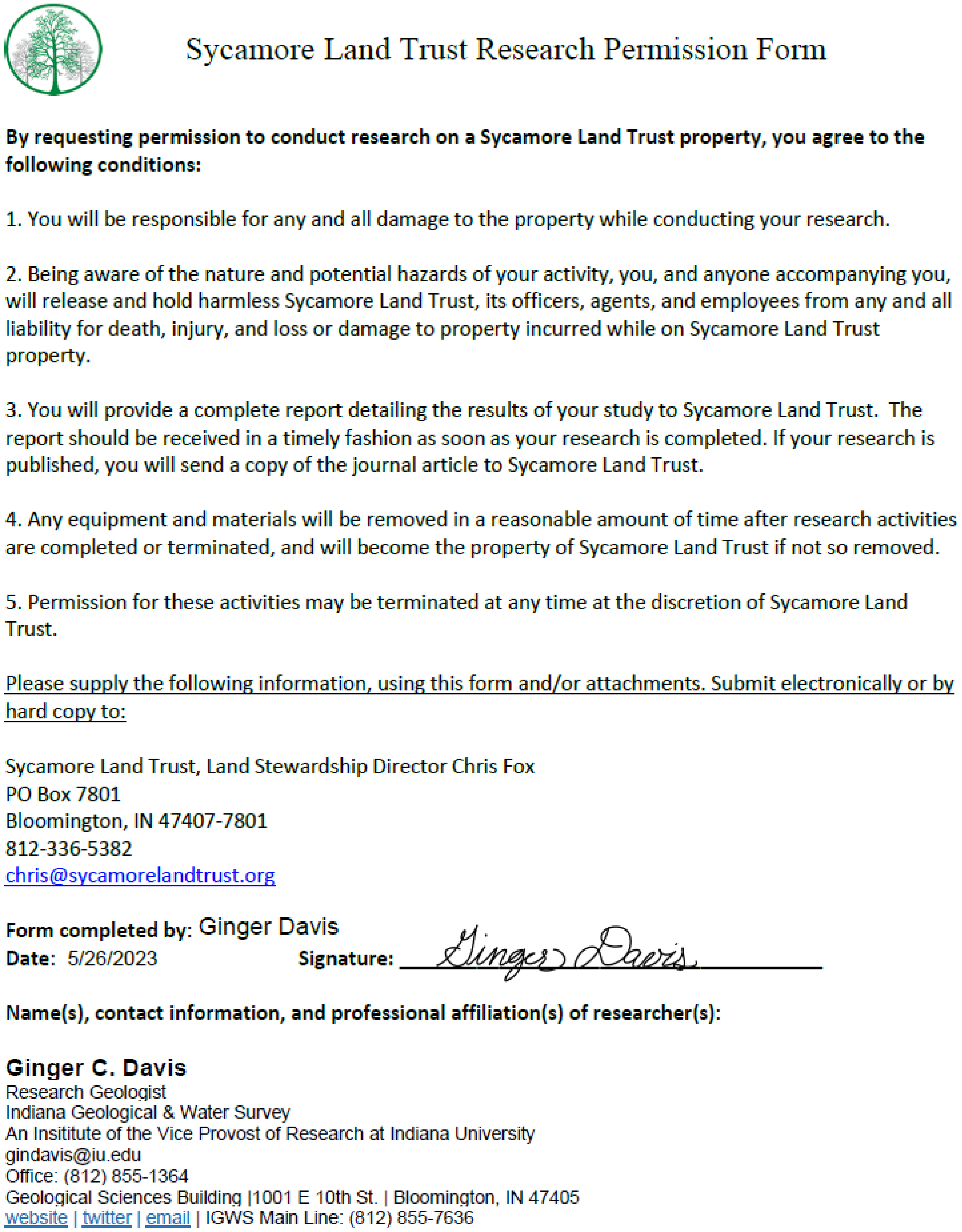
Lloyd, O. B., and Lyke, W. L., 1995, Ground water atlas of the United States, Segment 10, Illinois, Indiana, Kentucky, Ohio, Tennessee. Nos. 730-K: U.S. Geological Survey. https://doi.org/10.3133/ha730K.

Appendix A. Research Permission Form



Sycamore Land Trust Research Permission Form

By requesting permission to conduct research on a Sycamore Land Trust property, you agree to the following conditions:

1. You will be responsible for any and all damage to the property while conducting your research.

2. Being aware of the nature and potential hazards of your activity, you, and anyone accompanying you, will release and hold harmless Sycamore Land Trust, its officers, agents, and employees from any and all liability for death, injury, and loss or damage to property incurred while on Sycamore Land Trust property.

3. You will provide a complete report detailing the results of your study to Sycamore Land Trust. The report should be received in a timely fashion as soon as your research is completed. If your research is published, you will send a copy of the journal article to Sycamore Land Trust.

4. Any equipment and materials will be removed in a reasonable amount of time after research activities are completed or terminated, and will become the property of Sycamore Land Trust if not so removed.

5. Permission for these activities may be terminated at any time at the discretion of Sycamore Land Trust.

Please supply the following information, using this form and/or attachments. Submit electronically or by hard copy to:

Sycamore Land Trust, Land Stewardship Director Chris Fox
PO Box 7801
Bloomington, IN 47407-7801
812-336-5382
chris@sycamorelandtrust.org

Form completed by: Ginger Davis
Date: 5/26/2023 **Signature:** Ginger Davis

Name(s), contact information, and professional affiliation(s) of researcher(s):

Ginger C. Davis
Research Geologist
Indiana Geological & Water Survey
An Insititute of the Vice Provost of Research at Indiana University
gindavis@iu.edu
Office: (812) 855-1364
Geological Sciences Building |1001 E 10th St. | Bloomington, IN 47405
website | twitter | email | IGWS Main Line: (812) 855-7636

Number of people to be involved:

The on-site crew for the installation will be 6-7 people: 3 drill operators and 3-4 geologists or support staff. Once a monitoring well is installed, a 3-person crew will come to the site 3-4 times per year to monitor and maintain the well.

If acceptable, we would like to host a Groundwater Monitoring Network well install workshop for a small group (20 people) from the Indiana Water Monitoring Council, Groundwater Focus Committee on one day of the core/drilling operation.

Proposed starting and ending dates of research:

We would collect the core and install the well from Oct 30 – Nov. 10, 2023. We would then like to keep the well in service for at least 10 years (until January 2034), or up to 100 years (2124) if acceptable. The best monitoring wells are the ones where we can keep an active eye on the system for decades. Wells do require maintenance and cleaning to keep them in good working condition and may require more intense service after 30 years. It is hard to say how long the well can be maintained for accurate measurements, but we intend to maintain the well for the agreed-upon duration. If at any point it is deemed that the well is no longer able to measure the aquifer levels accurately, or the landowner wishes to terminate the agreement, the well would be plugged according to Indiana Administrative Code 312 IAC 13, and buried.

Research abstract or summary:

The goal of the Indiana Water Balance Network and its network of monitoring wells is to gather representative monitoring of environmental activities that measure the inflow, flux, and outflow of water within various systems (atmosphere, soil, and aquifer). Developing flow paths that define the movement through the hydrosphere within a variety of physiographic settings helps to define the variations seen across these systems. By including the collection of groundwater and aquifer data at multiple depths, the dynamics of the groundwater system can be assessed. As we evaluate the groundwater in the state, we are poised to find wells that can support a national- and regional-scale dataset for the assessment of important aquifers in Indiana. Our shared goals are to assess the baseline conditions and long-term trends in water levels in these aquifers and continue to drive the data collection. To that end, our monitoring network is expanding and redesigned to assess the best aquifers. With the additional wells drilled during this round, our network has grown to 18 wells in the National Groundwater Monitoring Network and an additional 24 in our internal monitoring network that represent Principal Aquifers of Alluvial and Glacial Origin and the Mississippian Aquifer, along with Secondary Hydrogeologic Regions of Other Aquifers.

Activities to be performed:

What equipment, processes, techniques, and methods will you be using?

Drilling services will be contracted from the Illinois State Geological Survey (ISGS). A truck-mounted drill rig using mud rotary drilling methods and wireline coring tools will be used to collect continuous soil and bedrock core. The 2.5-inch core will be obtained in 10-ft lengths. Cores will be discharged from the core barrel onto a half PVC pipe, rinsed to clean off the bentonite drilling mud, reviewed for a simplified field description, and packed into core boxes. Further detailed descriptions will be completed at the Indiana Geological and Water Survey's Material Testing Facility. Color identification and description will be performed after wetting, using the coding system in Thompson and Keith (2015). A stratigraphic column will then be created using the Windows™.NET program Column (v. 1.02). The core will be further sampled to analyze porosity and a pXRF (X-ray fluorescence) chemical makeup will be run on the bedrock samples. Unconsolidated core will be processed for grain size for the portion of overburden at the site. Each description includes the U.S. Department of Agriculture (USDA) texture with additional description for greater than 2 mm pebbles, Munsell color, hydrochloric acid reaction, lithologic code, and any miscellaneous features. Lithologic codes are based on a paper by Eyles, Eyles, and Miall (1983).

The 6-inch reamed well hole will be filled with a 0.010-inch slot, 2-inch inside-diameter PVC well screen, and a PVC bottom plug will be installed at the target depths. A sand pack will be placed around the well at the target aquifer depth. Bentonite pellets will be used to seal the remaining anulus of the well to prevent contamination of the well from surface water or upper aquifers. Waterproof caps will be placed on the top of the wells. A concrete surface seal and a well protective cover will be installed at grade or above grade. The protective cap is either a flush mount or pop-up steel casing depending on the agreed-upon installation method.

Spatial extent: over entire property, or over what portions?

We propose installing the monitoring well at the Cookson Preserve located in Greene County. The location is to be determined, but we are proposing that it be near the parking area at the SW edge of the property (39.0854, -86.9152). This insures it to be in an easily accessible area that will minimize disturbance to the site. The well base will be a 2-ft-by-2-ft concrete base with a 4-inch pop-up or flush mount port for access to the monitoring well.

Temporal extent: over what time period will the data collection take place?

Data would be collected hourly by an onsite data logger for a minimum of 10 years, from January 2024 through January 2034. If acceptable, the well would remain until it is no longer of value to either party.

How much soil, rock, and vegetation will be disturbed, moved, or removed?

The drilling rig and associated equipment may cause some disturbance where it is set up if the ground is wet or soft. Otherwise, the disturbance is limited to a small area where the well is installed. The lubricating muds and fines created during the drilling process would be spread across the drill location with water and would be incorporated into the existing soils naturally after one season. This area can be expected to be approximately a 25 ft^2 area. The lubricating mud is made from nontoxic clays. The 2.5-inch core to a depth of 400 feet is expected to be removed from the site.

Does this research require state, university, or other permits?

If yes, have they been obtained? Attach copies if so. If other permits will need to be obtained, Sycamore Land Trust will need copies before allowing the research.
No other permits are required until after the well is installed. Upon completion, a well log will be produced and supplied to DNR Division of Water for their water well record database. A copy of the form that is required to be completed upon completion of the well is attached (State Form 35680)

Additionally, a use agreement needs to be signed by Sycamore Land Trust and is attached here.

PERMISSION FOR USE AND ACCESS

WHEREAS, Sycamore Land Trust ("Licensor") is the owner of property
Property Owner Name

located at: Cookson Preserve, N State Road 157, Bloomfield, IN ("Premises");
Property Address (well location)

WHEREAS, The Trustees of Indiana University ("IU"), a body politic and corporate of the State of Indiana, through the Indiana Geological & Water Survey uses certain materials, equipment, and instruments that collect groundwater data (collectively, "Monitoring Wells");

WHEREAS, IU seeks permission on behalf of the Indiana Geological & Water Survey to access the Premises for the purpose of installing and maintaining Monitoring Wells on the Premises to collect groundwater data from the Premises ("Purpose");

NOW THEREFORE, Licensor agrees as follows:

1. Licensor hereby grants to IU, and to its agents and contractors, a non-exclusive, royalty-free license to access the Premises in connection with the Purpose.

2. The license granted herein will commence on the date of Licensor's execution below and will continue until Licensor's termination of the license or IU's removal of Monitoring Wells from the Premises, whichever occurs earlier. Licensor agrees to provide IU with at least ninety (90) day advance written notice of its decision to terminate this license.

3. Licensor acknowledges that IU retains ownership of and is responsible for maintaining all materials, equipment, and instruments installed by IU at the Premises. Licensor agrees to provide IU with at least ninety (90) day advance written notice of any request to remove the Monitoring Wells from the Premises.

4. Licensor agrees to provide landscaping services, at no charge to IU, around the Monitoring Wells to ensure that overgrown vegetation does not impact the well.

IN WITNESS WHEREOF, Licensor has caused this agreement to be executed by its duly authorized representative.

Property Owner Signature

By: John Lawrence

Name: Sycamore Land Trust

Title: Executive Director

Date: 10/17/2023

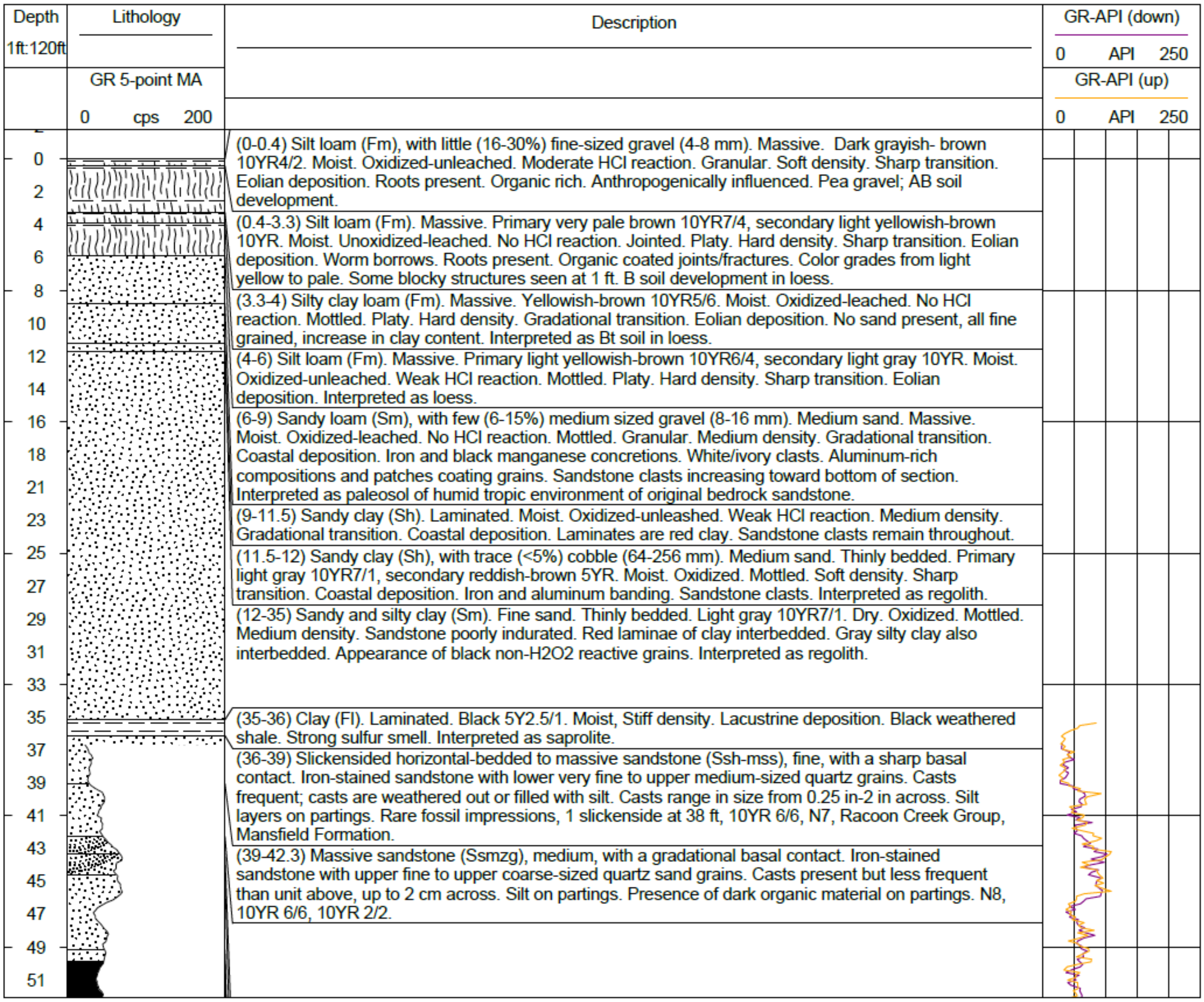
Appendix B. Bloomfield_N (Site ID: 282302) Lithology Description

INDIANA GEOLOGICAL & WATER SURVEY
INDIANA UNIVERSITY

Site ID: 282302	Date: 11/07/2023
Site Name: Bloomfield_N	Author: M. Sabaj
Latitude: 39.0853856	Elevation: 649 ft
Longitude: -86.91518303	NGWMN well

Legend

- Breccia
- Massive sand or sandstone
- Bedded sand or sandstone
- Crossbedded sand or sandstone
- Loess
- Silt, siltstone or silty shale
- Sandy or silty shale
- Clay or clay shale
- Limestone
- Fossiliferous clastic limestone
- Sandy limestone
- Argilaceous or shaly limestone
- Argilaceous or shaly dolomite
- Coal
- Glauconite
- Siderite
- Interbedded sandstone and siltstone
- Interbedded sandstone and shale
- Interbedded ripple-bedded sandstone and shale



(0-0.4) Silt loam (Fm), with little (16-30%) fine-sized gravel (4-8 mm). Massive. Dark grayish- brown 10YR4/2. Moist. Oxidized-unleached. Moderate HCl reaction. Granular. Soft density. Sharp transition. Eolian deposition. Roots present. Organic rich. Anthropogenically influenced. Pea gravel; AB soil development.

(0.4-3.3) Silt loam (Fm). Massive. Primary very pale brown 10YR7/4, secondary light yellowish-brown 10YR. Moist. Unoxidized-leached. No HCl reaction. Jointed. Platy. Hard density. Sharp transition. Eolian deposition. Worm borrows. Roots present. Organic coated joints/fractures. Color grades from light yellow to pale. Some blocky structures seen at 1 ft. B soil development in loess.

(3.3-4) Silty clay loam (Fm). Massive. Yellowish-brown 10YR5/6. Moist. Oxidized-leached. No HCl reaction. Mottled. Platy. Hard density. Gradational transition. Eolian deposition. No sand present, all fine grained, increase in clay content. Interpreted as Bt soil in loess.

(4-6) Silt loam (Fm). Massive. Primary light yellowish-brown 10YR6/4, secondary light gray 10YR. Moist. Oxidized-unleached. Weak HCl reaction. Mottled. Platy. Hard density. Sharp transition. Eolian deposition. Interpreted as loess.

(6-9) Sandy loam (Sm), with few (6-15%) medium sized gravel (8-16 mm). Medium sand. Massive. Moist. Oxidized-leached. No HCl reaction. Mottled. Granular. Medium density. Gradational transition. Coastal deposition. Iron and black manganese concretions. White/ivory clasts. Aluminum-rich compositions and patches coating grains. Sandstone clasts increasing toward bottom of section. Interpreted as paleosol of humid tropic environment of original bedrock sandstone.

(9-11.5) Sandy clay (Sh). Laminated. Moist. Oxidized-unleashed. Weak HCl reaction. Medium density. Gradational transition. Coastal deposition. Laminates are red clay. Sandstone clasts remain throughout.

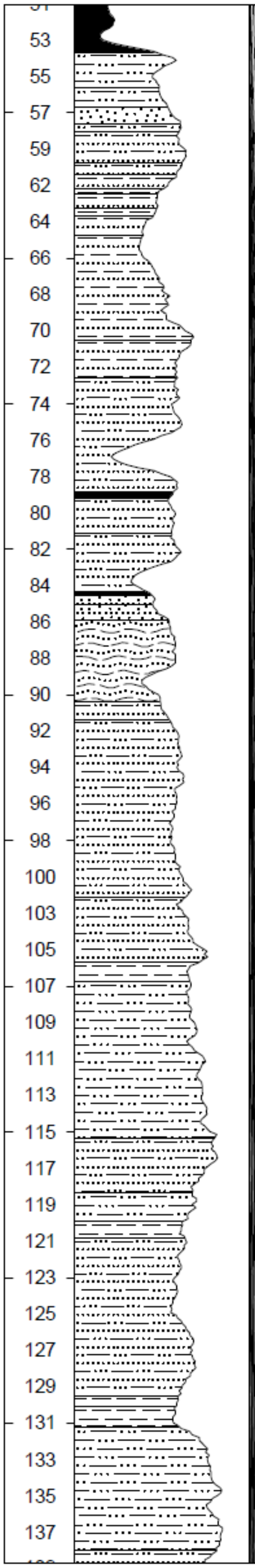
(11.5-12) Sandy clay (Sh), with trace (<5%) cobble (64-256 mm). Medium sand. Thinly bedded. Primary light gray 10YR7/1, secondary reddish-brown 5YR. Moist. Oxidized. Mottled. Soft density. Sharp transition. Coastal deposition. Iron and aluminum banding. Sandstone clasts. Interpreted as regolith.

(12-35) Sandy and silty clay (Sm). Fine sand. Thinly bedded. Light gray 10YR7/1. Dry. Oxidized. Mottled. Medium density. Sandstone poorly indurated. Red laminae of clay interbedded. Gray silty clay also interbedded. Appearance of black non-H_2O_2 reactive grains. Interpreted as regolith.

(35-36) Clay (Fl). Laminated. Black 5Y2.5/1. Moist, Stiff density. Lacustrine deposition. Black weathered shale. Strong sulfur smell. Interpreted as saprolite.

(36-39) Slickensided horizontal-bedded to massive sandstone (Ssh-mss), fine, with a sharp basal contact. Iron-stained sandstone with lower very fine to upper medium-sized quartz grains. Casts frequent; casts are weathered out or filled with silt. Casts range in size from 0.25 in-2 in across. Silt layers on partings. Rare fossil impressions, 1 slickenside at 38 ft, 10YR 6/6, N7, Racoon Creek Group, Mansfield Formation.

(39-42.3) Massive sandstone (Ssmzg), medium, with a gradational basal contact. Iron-stained sandstone with upper fine to upper coarse-sized quartz sand grains. Casts present but less frequent than unit above, up to 2 cm across. Silt on partings. Presence of dark organic material on partings. N8, 10YR 6/6, 10YR 2/2.



(42.3-43.4) Rooted massive- to cross-bedded sandstone (Ssm-xrg), fine, with a gradational basal contact. Iron-stained sandstone with upper fine quartz sand grains and silt on partings. Weathered-out casts up to 1.2 cm across, some filled with silt. Ironstones ranging from 1 mm to 2.5 cm in size, 10YR 6/6, 5YR 3/4, N6.

(43.4-44.7) Rooted massive- to horizontal-bedded sandstone (Ssm-hrs), fine, with a sharp basal contact. Iron-stained at top of unit. Casts ranging from 5 mm to 2.5 cm in size, some weathered out, some filled with silt. Very fine pyrite grains and silt on partings. Lower fine to upper fine sand grains. Thin, dark shale laminations intermittently throughout. N7, 5 YR 6/6.

(44.7-49.4) Massive sandstone (Ssmzs), medium, with a sharp basal contact. Iron-stained sandstone with fine to upper medium-sized quartz grain sand. Casts up to 4 cm across, weathered out or containing silt. Mud layers up to 2.5 in thick. Iron concretions. Dark organic material on partings.10YR 8/6, 5YR 5/6, N6.

(49.4-50.1) Massive to horizontal-bedded sandstone (Ssm-hzg), fine, with a gradational basal contact. Lower very fine to upper medium-sized quartz sand grains. Weathered-out casts and casts containing silt. Dark organic material on partings as well as in casts. Thin laminations of dark organic material. N7, N1.

(50.1-50.9) Coal (Orzzz), N1.

(50.9-54) Not present/recovered. Gamma Interpreted as coal.

(54-56) Not present/recovered. Gamma Interpreted as siltstone.

(56-57.1) Massive siltstone and sandstone (Ft/Ssmzg), silt, with a gradational basal contact. Sandy siltstone. Organic material concretions on partings. 5Y 6/1, N6.

(57.1-58) Rooted massive sandstone and siltstone (Ss/Ftmrg), medium, with a gradational basal contact. Lower very fine-grained silty sandstone. Organic material concretions on partings. 5Y 6/1, N3.

(58-58.5) Rooted massive siltstone and sandstone (Ft/Ssmrg), silt, with a gradational basal contact. Siltstone with lower very fine-grained sand. Dark organic material on partings. 5Y 6/1.

(58.5-60.2) Bioturbated horizontal-bedded siltstone and sandstone (Ft/Sshbg), silt, with a gradational basal contact. Interbedded siltstone and sandstone. Lower very fine sand grains. Ironstone concretions filling casts. 5Y 4/1, 10R 3/4.

(60.2-60.9) Bioturbated horizontal-bedded siltstone and sandstone (Ft/Sshbs), silt, with a sharp basal contact. Interbedded siltstone and sandstone. Lower very fine sand grains. Organic material concretions on partings. N5, 5Y 4/1.

(60.9-61.7) Bioturbated horizontal-bedded shale and sandstone (Fs/Sshbg), clay, with a gradational basal contact. Interbedded shale and sandstone. Lower very fine sand grains. Ironstone concretions filling casts. N3, N6.

(61.7-62) Not present/recovered. Gamma interpreted as shale and sandstone.

(62-62.8) Bioturbated horizontal-bedded shale and sandstone (Fs/Sshbg), clay, with a gradational basal contact. Shale with thin sandstone laminations. Lower very fine sand grains. N4, N7.

(62.8-63.2) Bioturbated to disturbed-bedded horizontal-bedded shale and sandstone (Fs/Sshb-dg), clay, with a gradational basal contact. Interbedded shale and sandstone. Rare brachiopod fossil at base of unit. N4, N7, 10 YR 6/2.

(63.2-64.3) Bioturbated to disturbed-bedded horizontal-bedded shale and sandstone (Fs/Sshb-dg), clay, with a gradational basal contact. Interbedded shale and sandstone with lower very fine grains. N4, N7, 10YR 6/2.

(64.3-70.2) Bioturbated to disturbed-bedded horizontal-bedded sandstone and shale (Ss/Fshb-ds), very fine, with a sharp basal contact. Sandstone interlaminated with shale. Heavily bioturbated with pyrite grains up to lower very coarse-sized. Silt on partings. N4, N7, 10 YR 6/2.

(70.2-72.4) Bioturbated and disturbed-bedded horizontal-bedded sandstone and claystone (Ss/Fchb/ds), medium, with a sharp basal contact. Poorly sorted sandstone with sub-angular to sub-rounded grains. Sand is predominately quartz of lower very fine to upper medium-sized grains. Organic clay-rich material present as drapes. Mica on bedding planes and siderite bands throughout unit. N3.

(72.4-78.8) Fossiliferous and bioturbated horizontal-bedded sandstone and siltstone (Ss/Fthf/bs), medium, with a sharp basal contact. Sandstone with organic material concretions on partings. Plant fossils seen as carbonaceous wood fragments. N4.

(78.8-79.1) Coal and claystone (Or/Fczzs), with a sharp basal contact. Heavily damaged by core retrieval. N3.

(79.1-81.1) Fossiliferous horizontal-bedded sandstone and siltstone (Ss/Fthfg), fine, with a gradational basal contact. Plant fossils and dark organic carbonaceous material seen on bedding planes. Bioturbated with gypsum concretions filling burrows. Siderite nodules also present. N7, N6.

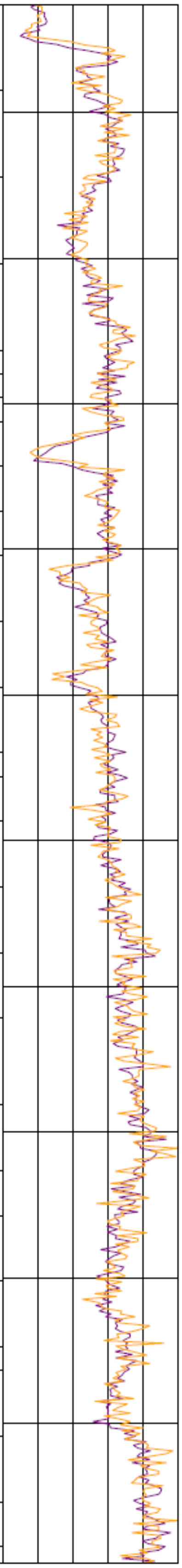
(81.1-84.4) Fossiliferous and disturbed-bedded horizontal-bedded siltstone and sandstone (Ft/Sshf/ds), silt, with a sharp basal contact. Sand is very fine grained. Abundant flakes of organic material as well as plant fossils on partings. Gypsum concretions filling burrows. N7.

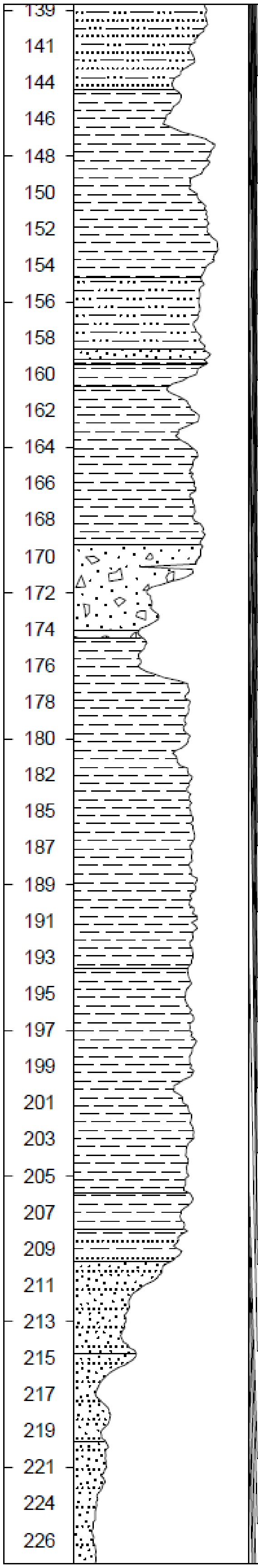
(84.4-84.6) Coal (Orzzs), with a sharp basal contact. N3.

(84.6-85.1) Mottled horizontal-bedded sandstone (Sshms), fine, with a sharp basal contact. Mottled sandstone with organic-rich material on partings and an iron-rich cement containing gypsum. N8, N5, 10YR 5/4.

(85.1-86) Disturbed-bedded and fossiliferous horizontal-bedded sandstone (Sshd/fs), fine, with a sharp basal contact. Sandstone with minor rooting. Siderite nodules containing gypsum are present. Contains organic-rich plant fossils. N7.

(86-90.6) Bioturbated wavy-bedded shale and siltstone (Fs/Ftwbs), clay, with a sharp basal contact. Shale with siderite bands and micro faults throughout. Very fine mica particles on partings. N7, N4.





(90.6-91.6) Flaser-bedded siltstone and sandstone (Ft/Ssfzs), silt, with a sharp basal contact. Siltstone with very fine sand grains. Mica flakes and dark organic matter present on partings. Thin silt stringers present. N7.

(91.6-101.6) Bioturbated and fossiliferous wavy-bedded and flaser-bedded sandstone and siltstone (Ss/Ftw/fb/fg), very fine, with a gradational basal contact. Sandstone with very fine-grained quartz sand. Bedding alternates between wavy and flaser. Heavily bioturbated, evidence of micro faults creating disturbed bedding. Abundant mica flakes present on partings as well as dark organic-rich material. Siderite bands are present throughout. Contains plant fossils. N8, N4, 10YR 5/4.

(101.6-105.3) Bioturbated and disturbed-bedded horizontal-bedded to cross-bedded siltstone and sandstone (Ft/Ssh-xb/ds), silt, with a sharp basal contact. Siltstone containing siderite bands and nodules. Gypsum concretions filling casts present. Mica flakes of silt size present on partings. N4, 10 YR 5/4.

(105.3-106.4) Fossiliferous horizontal-bedded claystone (Fchfz), clay, rubble/broken. Marine and plant fossils present. Slickensided. N3.

(106.4-115.2) Horizontal-bedded to cross-bedded siltstone (Fth-xzs), silt, with a sharp basal contact. Clay-rich siltstone with horizontal to inclined bedding. Mica flakes present on partings. Siderite bands present. N4, 5Y 6/1.

(115.2-118.3) Fossiliferous and bioturbated horizontal-bedded siltstone, siderite, and sandstone (Ft/Sd/Sshf/bs), silt, with a sharp basal contact. Siltstone with lower very fine to very fine sand grains. Mica flakes and dark carbonaceous organic material present on partings. 10 YR 5/4, N5, N8.

(118.3-119.9) Horizontal-bedded siltstone (Fthzs), silt, with a sharp basal contact. Siltstone with coarse grains of carbonaceous material. Very fine-grained micas present. N5.

(119.9-120.8) Fossiliferous horizontal-bedded shale (Fshfs), clay, with a sharp basal contact. Thinly laminated shale with minor sand laminations toward base of unit. Plant fossils present, possible algal mat. Dark carbonaceous material present. N2, N6.

(120.8-129.7) Horizontal-bedded siltstone, siderite, and sandstone (Ft/Sd/Sshzg), silt, with a gradational basal contact. Minor amounts of quartz sandstone. Mica flakes and dark organic material on partings. N5, N8, 10 YR 5/4.

(129.7-130.3) Horizontal-bedded shale and siderite (Fs/Sdhzg), clay, with a gradational basal contact. Clay-rich shale with siderite laminations and potential bioturbation. N6, 10 YR 5/4.

(130.3-131.5) Horizontal-bedded shale (Fshzs), clay, with a sharp basal contact. Organic-rich shale. N3.

(131.5-138.4) Horizontal-bedded shale to siltstone (Fs-Fthzg), clay, with a gradational basal contact. Shale and siltstone with siderite bands. Slickensides near top of unit and carbonaceous organic material throughout unit. Poorly indurated with a blocky texture. 10YR 5/4, N4, N6-N7.

(138.4-143.9) Horizontal-bedded siltstone and sandstone (Ft/Sshzg), silt, with a gradational basal contact. Sandy siltstone with grains being lower very fine with some lower medium-sized grains. Mica flakes present on partings. Base of unit is more clay-rich. N8-N7.

(143.9-154.5) Horizontal-bedded shale (Fshzz), clay, contains plant fossils. N6.

(154.5-158.5) Fossiliferous horizontal-bedded siltstone to claystone (Ft-Fchfg), silt, with a gradational basal contact. Clay-rich siltstone containing dark carbonaceous material and fossilized plant fragments. Sparse very fine-grained mica on partings. N5.

(158.5-159.1) Fossiliferous and mottled massive sandstone (Ssmf/ms), medium, with a sharp basal contact. Heavily iron stained sandstone containing reworked clay particles making up a clay "breccia" with fine grained sand. Clay particles are on the mm scale. 10YR 4/2.

(159.1-159.4) Slickensided massive claystone (Fcmsi), clay, with an irregular basal contact. Claystone with slickensides and dark organic particles. N5.

(159.4-160.6) Horizontal-bedded shale (Fshzi), clay, with an irregular basal contact. Thinly laminated silty shale containing abundant mica and minor very fine dark organic particles on bedding planes. N4 and 5Y 6/1.

(160.6-169.5) Bioturbated shale (Fszbs), clay, with a sharp basal contact. Shale containing lenses of sand seen as sand filled burrows throughout. Contains occasional mica, siderite, and iron-stained oxidized pyrite. N3, 10 YR 4/2.

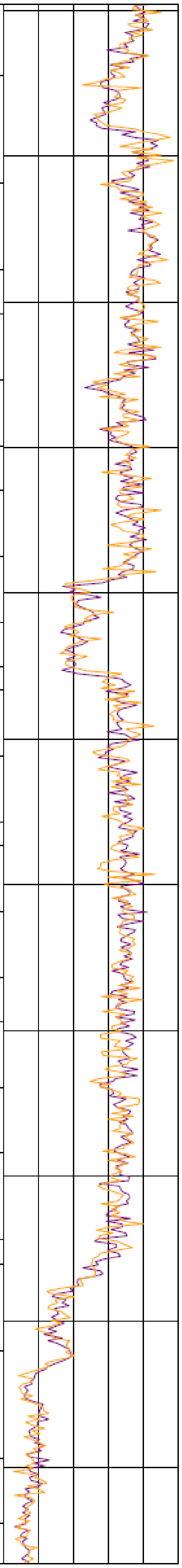
(169.5-174.3) Mottled massive breccia (Brmms), gravel, with a sharp basal contact. Clay-rich calcareous sandstone breccia with silt to pebble sized sands. Contains angular to rounded chert, siderite, and recrystallized fossils. Heavily siliciclastic with very fine pyrite throughout. N5, N7, 10 YR 7/4, 10 YR 6/2, 10 YR 6/6, and 10 YR 8/2.

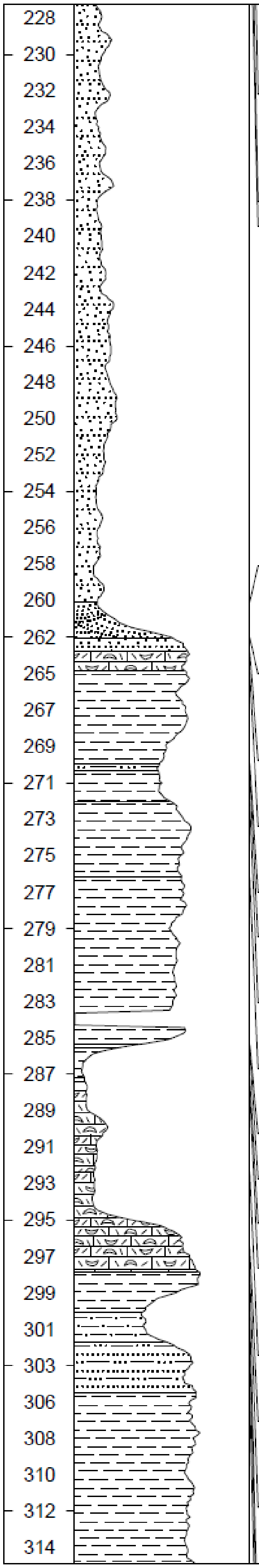
(174.3-174.8) Massive siderite (Sdmzs), with a sharp basal contact. 5Y 6/1, N5, and 5Y 4/1.

(174.8-193.4) Bioturbated horizontal-bedded shale (Fshbg), clay, with a gradational basal contact. Shale with burrows filled with very fine-grained sand. Contains minor very fine to fine-grained carbonaceous material and lower very fine to upper fine-grained siderite grains. Has rare pyrite nodules and rare plant fossils and occasional slickensides. N3 and 5Y 6/1.

(193.4-206) Bioturbated horizontal-bedded shale (Fshbs), clay, with a sharp basal contact. Shale with siderite bands up to 2 in thick and fine siderite grains with some upper coarse grains. Has sand filled burrows up to 6-7 mm in size, sand grains are poorly sorted, angular to rounded and range from lower very fine-grained to upper very fine-grained. Contains very fine pyrite grains and pyrite nodules. 5Y 6/1, N4, and N3.

(206-208.1) Bioturbated and disturbed-bedded horizontal-bedded shale (Fshb/ds), clay, with a sharp basal contact. Shale with some sand laminations, sand-filled burrows, and common pyrite nodules. One in siderite bed at top of unit (5Y 6/1) and rare thin laminations throughout. N3 and N7.





(208.1-209.9) Bioturbated wavy-bedded sandstone and shale (Ss/Fswbs/i), medium, with a sharp and irregular basal contact. Poorly sorted, subangular to subrounded upper fine to lower medium quartz sand with some pyrite nodules. Siderite laminations present at 208.17 and 208.25 ft. Poorly developed slickensides in shale laminations. Heavily damaged by core retrieval. N8 to N7 and N3.

(209.9-215.1) Horizontal-bedded and flaser-bedded sandstone (Ssh/fzz), medium, poorly sorted, subangular to subrounded upper fine to lower medium quartz sand with minor calcite cement. Siderite laminations present at top of unit. Clay drapes are organic rich. Small pyrite nodules throughout. Very porous. 211.4 to 212.2 ft heavily damaged by core retrieval and appears to be clay and organic-rich shale with sand-filled burrows. 10YR 6/2, 10YR 7/4, N7 to N4.

(215.1-220) Not recovered. Gamma interpreted as sandstone.

(220-260.5) Horizontal-bedded, cross-bedded, and flaser-bedded sandstone (Ssh/x/fzs/i), medium, with a sharp and irregular basal contact. Poorly sorted, subangular to subrounded lower medium to upper medium sand. Localized zones of carbonate cement, increased silt content and/or iron staining. Very porous with moldic porosity. Fossils include brachiopods, forams, horn coral, and recrystallized fossil fragments. Siderite and pyrite concretions up to 0.4 in. Organic particles throughout with rare glauconitic pellets and some coal stringers present. 10YR 6/2, N7 to N6, 5Y 6/1, 5GY 6/1, N3, 10YR 5/4.

(260.5-262.5) Cross-bedded sandstone (Ssxzs), medium, with a sharp basal contact. Poorly sorted, lower fine to upper medium sand with dark lithics, organic particles (organic-rich laminations), common pyrite nodules and concretions and carbonate cement. Recrystallized fossil fragments. Few glauconite-rich grains. Very porous in zones. Vertical fractures present, some with calcite and pyrite. 10YR 6/2, 5Y 6/1, N6 and N3.

(262.5-263.3) Horizontal-bedded sandstone (Sshzs/i), medium, with a sharp and irregular basal contact. Upper fine to lower medium sand with calcite cement. Dark lithics and iron-rich or iron-stained grains throughout. Dark lithics increase with depth. Few organic particles and small pyrite nodules. 5G 4/1, N6, N5. Mixing zone?

(263.3-264.4) Fossiliferous massive grainstone (Lgmfs/i), grainstone, with a sharp and irregular basal contact. Abundant rounded coated grains. Local patches of sparite. Small disseminated pyrite crystals. 5YR 5/2. West Baden Group, Reelsville Limestone.

(264.4-269.6) Slickensided horizontal-bedded claystone (Fchsz), clay, with lighter-colored carbonate rich bands. Pyrite crystals present at the top of the unit and silt increases toward the base. 5G 4/1 and 5GY 5/2. Sample Formation.

(269.6-270) Not recovered. Gamma interpested as siltstone.

(270-271.7) Slickensided horizontal-bedded claystone (Fchsg), clay, with a gradational basal contact. Lighter colored carbonate rich bands. Pyrite crystals present at the top of the unit and silt increases toward the base. 5G 4/1 and 5GY 5/2.

(271.7-276) Slickensided horizontal-bedded claystone (Fchsg), clay, with a gradational basal contact. Silt-rich zones which contain small pyrite crystals. Slickensides and iron staining present near base as clay content increases. N6 and 5G 6/1.

(276-285.4) Slickensided horizontal-bedded claystone and shale (Fc/Fshss), clay, with a sharp basal contact. Contains thin siderite bands and small pyrite crystals. Organic flakes and mica on partings. N4 to N5.

(285.4-285.6) Fossiliferous horizontal-bedded claystone (Fchfs), clay, with a sharp basal contact. Contains crinoids, dark rounded grains (chert), and abundant pyrite. N7 to N6.

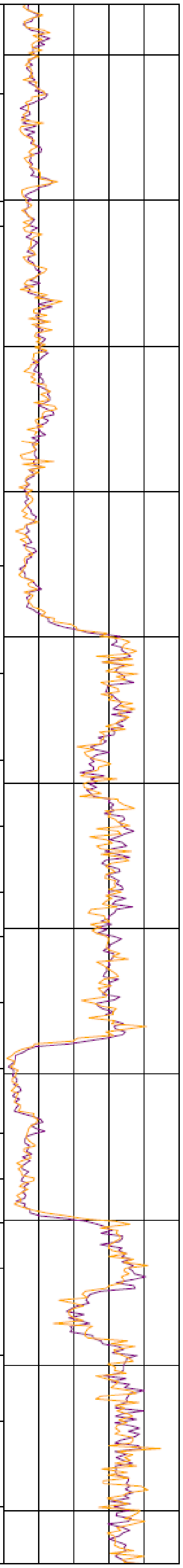
(285.6-287.3) Horizontal-bedded claystone and shale (Fc/Fshzz), clay, with carbonate-rich laminations and small pyrite crystals. N4 to N5 and N6.

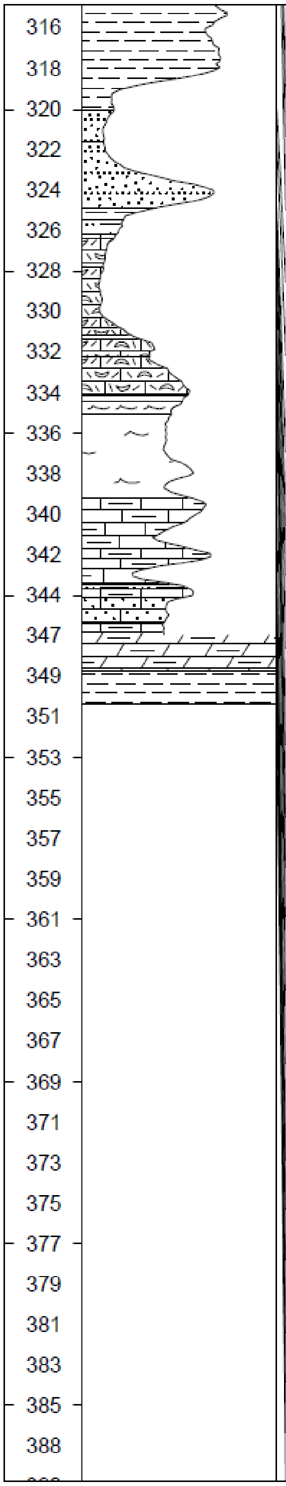
(287.3-288) Not recovered. Gamma interpreted as claystone and shale.

(288-292.6) Fossiliferous and oolitic massive grainstone (Lgmf/os), grainstone, with a sharp basal contact. Lower medium rounded and elliptical coated grains. Fossils include crinoids, forams, and bryozoa. Moldic porosity with pockets of sparite. Pyrite crystals. 5Y 6/1 to 5B 5/1. Beaver Bend Limestone.

(292.6-296.8) Fossiliferous and peloidal horizontal-bedded wackestone and packstone (Lw/Lphf/pg), wackestone, with a gradational basal contact. Fossils include crinoids, brachiopods, forams, and ostracods. Argillaceous partings, peloids, and small pyrite crystals. N6, 10YR 6/2.

(296.8-298.2) Fossiliferous and peloidal horizontal-bedded grainstone (Lghf/ps), grainstone, with a sharp basal contact. Small pyrite crystals, peloids, and fossil fragments. Fossils include criniods, brachiopods, forams, and ostracods (upper very coarse to lower medium). Sparite present in pockets and replacing fossils. N4 to N3.





(298.2-300.5) Bioturbated and slickensided horizontal-bedded claystone to shale (Fc-Fshb/sz), clay, contains very fine sand filled burrows (horizontal and vertical). Pyrite present in burrows and as small nodules. Silt-sized organic flakes and mica on partings. N4. Bethel Formation.

(300.5-302.2) Slickensided horizontal-bedded mudstone and siltstone (Fm/Fthss), clay, with a sharp basal contact. Siderite lenses. Poorly developed slickensides. Mica and organic flakes on partings. N5.

(302.2-305) Bioturbated flaser-bedded and wavy-bedded siltstone and sandstone (Ft/Ssf/wbz), silt, calcareous cement in top half of unit. Pyrite nodules present. Mica present on clay-rich partings. 5GY 6/1 and N5.

(305-319.9) Bioturbated and slickensided horizontal-bedded shale, with a sharp basal contact (Fshb/ss), clay, silt-filled burrows with some pyrite, pyrite-rich laminations, poorly developed slickensides, and organic flakes on partings. N5.

(319.9-321.5) Rooted horizontal-bedded sandstone (Sshrg), medium, with a gradational basal contact. Poorly sorted, subrounded upper very fine to lower fine quartz sand. Contains minor bioturbation and pyrite nodules. Rootlets lessen with depth. Mica on organic-rich clay partings. N7 and 5Y 6/1.

(321.5-324.9) Horizontal-bedded sandstone (Sshzs), medium, with a sharp basal contact. Poorly sorted, subrounded to rounded, upper very fine to lower fine quartz sand. Minimal rootlets. Porous sand with clay drapes that have a greenish tint and calcareous cement. Common small pyrite nodules. N7 and 5Y 6/1.

(324.9-325.5) Bioturbated and rooted horizontal-bedded sandstone and claystone (Ss/Fchb/rs), medium, with a sharp basal contact. Poorly sorted lower very fine sand to silt. Heavily bioturbated. Mica flakes on partings. Pyrite concentrated at basal contact. N6 and N4.

(325.5-326.2) Claystone to siltstone (Fc-Ftzzg), clay, with a gradational basal contact. Poorly developed slickensides. N4 and 5G 4/1.

(326.2-326.4) Limestone-clast conglomerate (Glzzs/i), gravel, with a sharp and irregular basal contact. Matrix-supported conglomerate with limestone clasts and some granules to upper coarse sand clasts. Pyrite present along contact. 5G 4/1. Blue River Group, Paoli Limestone.

(326.4-327.9) Mottled and fossiliferous horizontal-bedded and interlaminated/interbedded packstone and wackestone (Lp/Lwh/im/fi), packstone with an irregular basal contact. Packstone contains pyrite replacement and nodules and crioinds (upper coarse to lower medium). Wackestone contains skeletal fragments up to .25 in, pyrite nodules and stylolites. 5Y 6/1, N6, 5Y 2/1.

(327.9-331.3) Fossiliferous and oolitic horizontal-bedded grainstone (Lghf/ot), grainstone, with a stylolite basal contact. Rounded and elliptical coated grains (pseudo ooids) with sparite cement. Small pyrite crystals between or replacing the center of grains. Stylolites every 0.5 ft. 5Y 6/1.

(331.3-331.5) Massive breccia (Brmzs/i), gravel, with a sharp and irregular basal contact. Lower fine to upper fine rounded sand grains. Contains glauconite rich clay and carbonate clasts. 5G 6/1 and 5Y 6/1.

(331.5-332.4) Fossiliferous and oolitic massive grainstone (Lgmf/os), grainstone, with a sharp basal contact. Coated grains with sparite and pyrite in matrix. Crinoid debris present in minor amounts. 5Y 6/1.

(332.4-334.4) Fossiliferous horizontal-bedded packstone and claystone (Lp/Fchfs), packstone, with a sharp basal contact. Contains glauconite rich clay, abundant brachiopods and few crinoids. Small pyrite crystals and laminations present. Packstone contains lower very fine sand. 5G 6/1 and N7.

(334.4-339.6) Bioturbated horizontal-bedded claystone and siltstone (Fc/Fthbg), clay, with a gradational basal contact. Glauconitic claystone with pyrite crystals in the silt laminations and burrows (up to granular size). 5G 6/1 and N8.

(339.6-343.9) Bioturbated, fossiliferous, and slickensided horizontal-bedded claystone and argillaceous limestone (Fc/Lahb/f/sg), clay, with a gradational basal contact. Argillaceous limestone contains very fine sand and dark lithics. Common brachiopods and recrystallized crinoids. Pyrite crystals throughout (very fine to granule-size crystals). Clay is glauconite-rich. 5G 6/1 and N7.

(343.9-344.2) Horizontal-bedded siltstone (Fthzs), silt, with a sharp basal contact. Contains pyrite nodules (upper medium to coarse grained). 5GY 6/1.

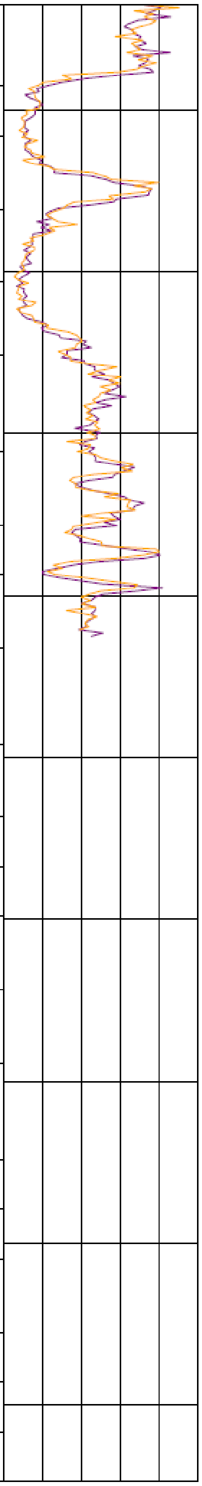
(344.2-344.6) Horizontal-bedded argillaceous limestone (Lahzs), mudstone, with a sharp basal contact. Minor bioturbation. N8 to N6.

(344.6-345.9) Fossiliferous massive wackestone (Lwmft), wackestone, with a stylolitic basal contact. Sandy limestone with recrystallized fossils (primarily crinoids), pyrite crystals, dark lithics and upper very fine sand. Pyrite crystals are concentrated along basal contact. 5Y 6/1.

(345.9-346.3) Fossiliferous horizontal-bedded claystone and wackestone (Fc/Lwhfs), clay, with a sharp basal contact. Glauconitic claystone and wackestone with recrystallized fossils. 10G 6/2 and 5Y 6/1.

(346.3-348.3) Massive argillaceous dolostone (Damzg), mudstone, with a gradational basal contact. Contains pyrite crystals and irregular layers of sand. 5G 8/1 to 5G 6/1.

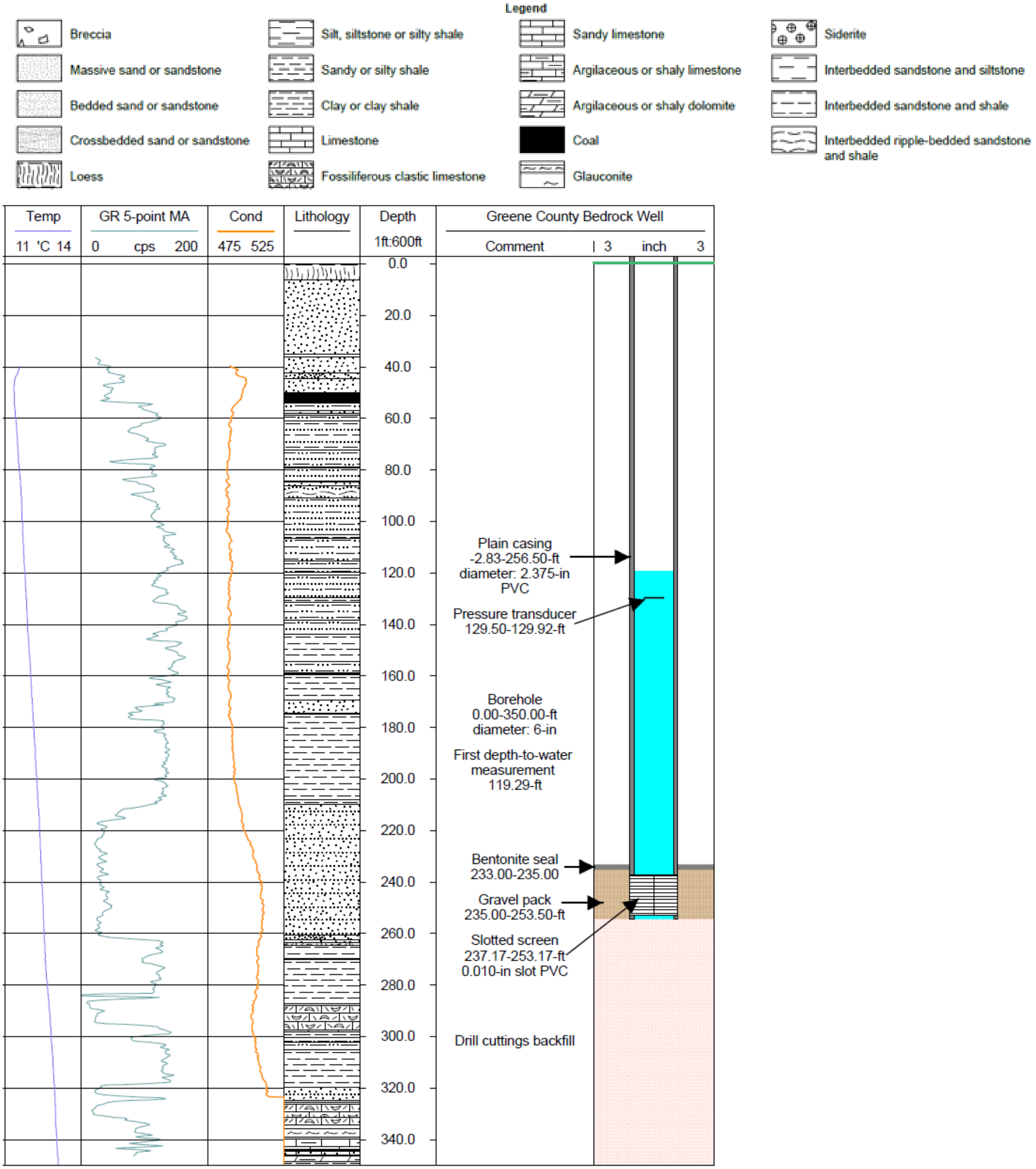
(348.3-350) Slickensided horizontal-bedded claystone (Fchsz), clay, abundant pyrite crystals throughout (very fine to granule-sized nodules). 5G 6/1.



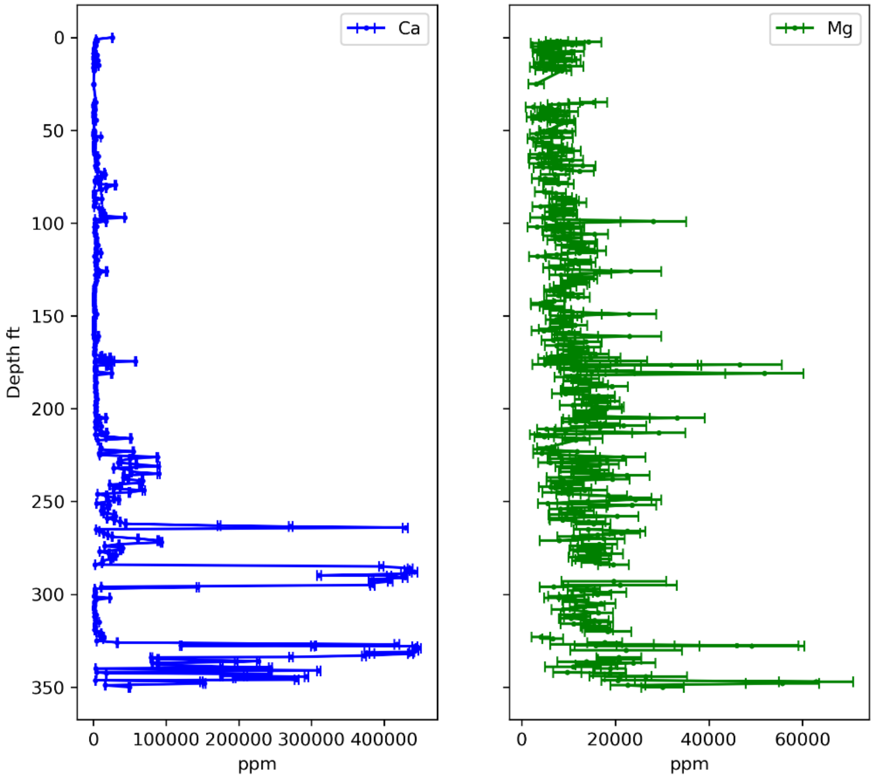
Appendix C: Bloomfield_N (Site ID: 282302) Well Diagram

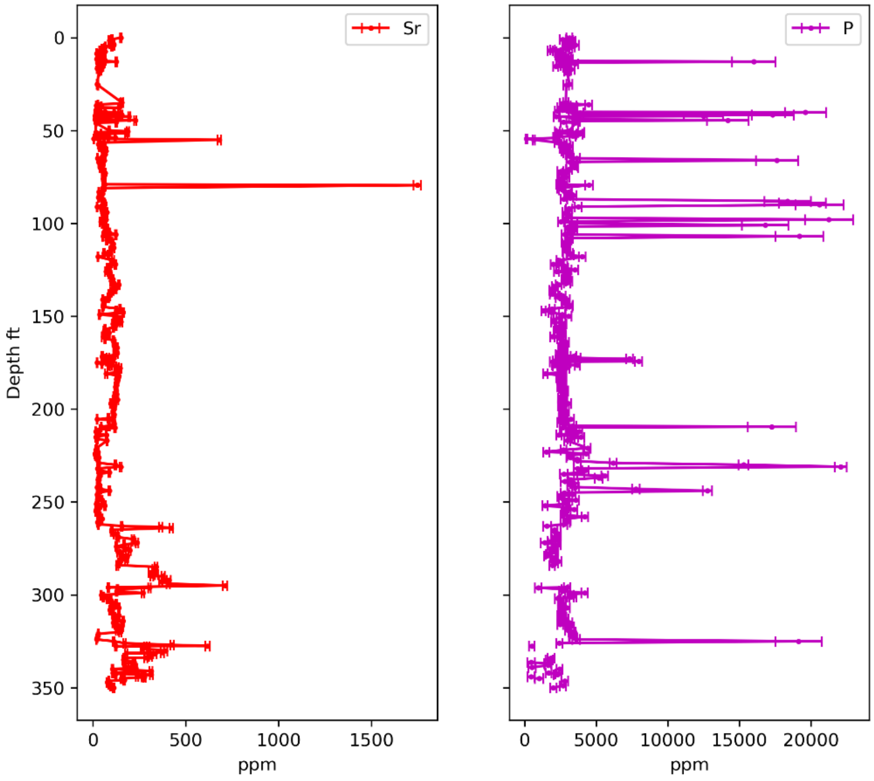
INDIANA GEOLOGICAL & WATER SURVEY
INDIANA UNIVERSITY

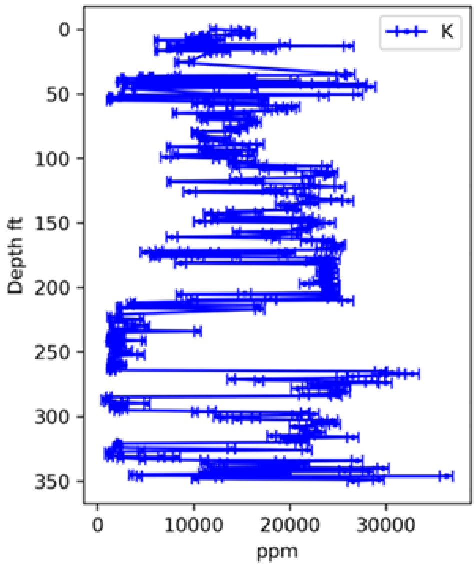
Site ID: 282302	Date: 11/07/2023
Site Name: Bloomfield_N	Author: M. Sabaj
Latitude: 39.0853856	Elevation: 649 ft
Longitude: -86.91518303	NGWMN well



Appendix D. PXRF Results for Bloomfield_N



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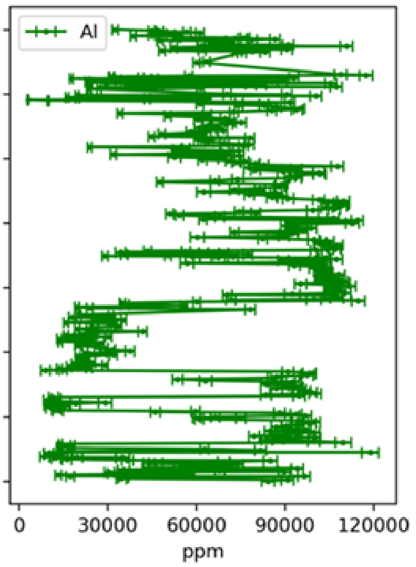
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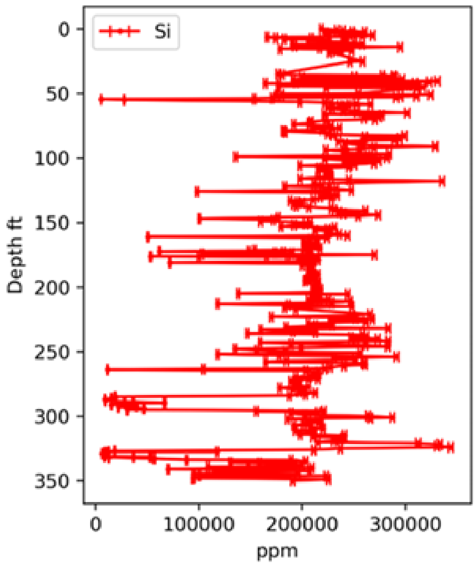
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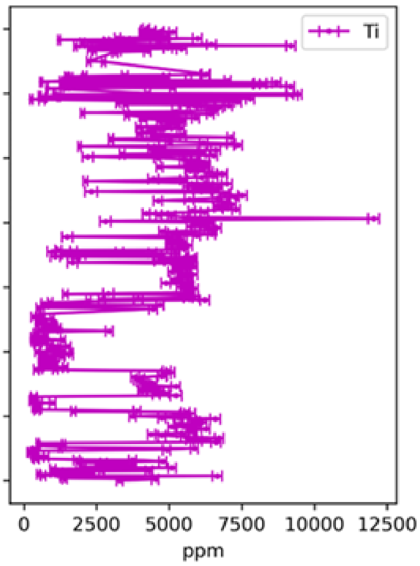
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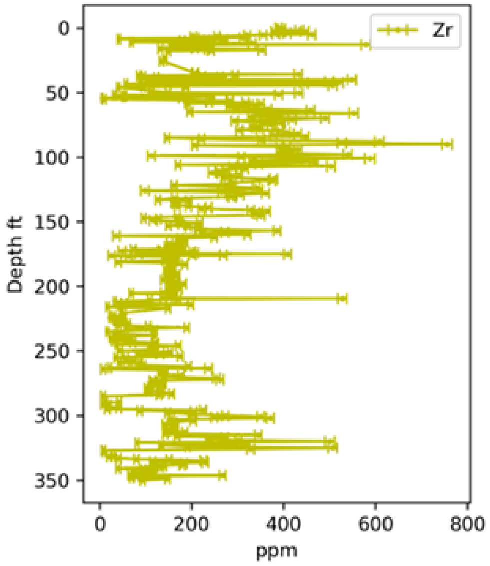
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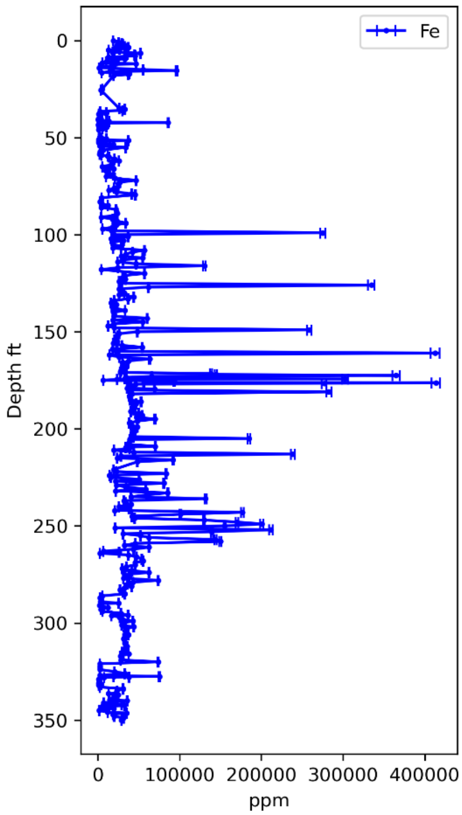
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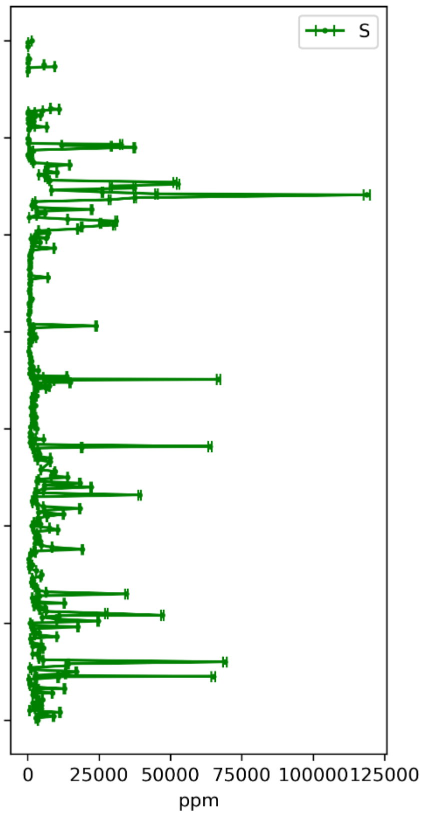
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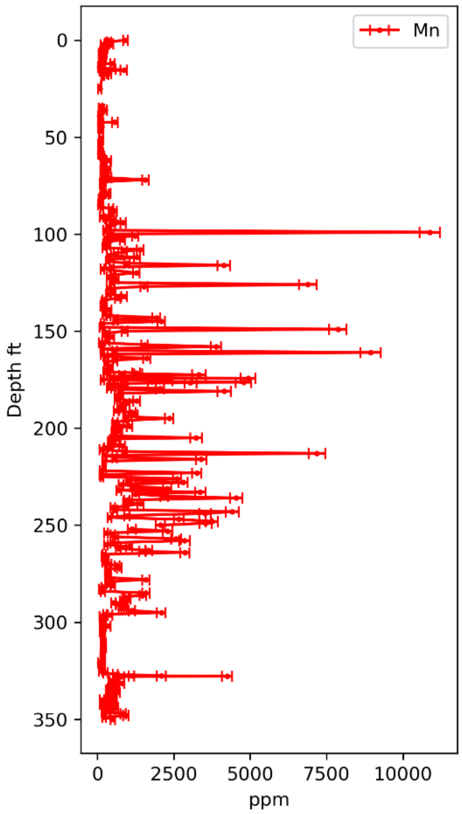
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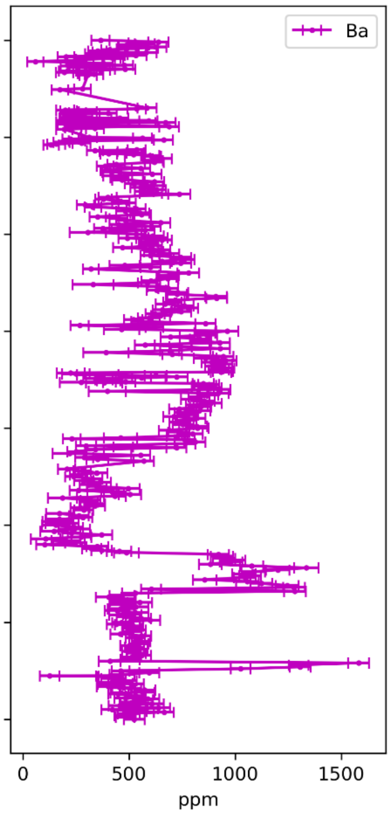
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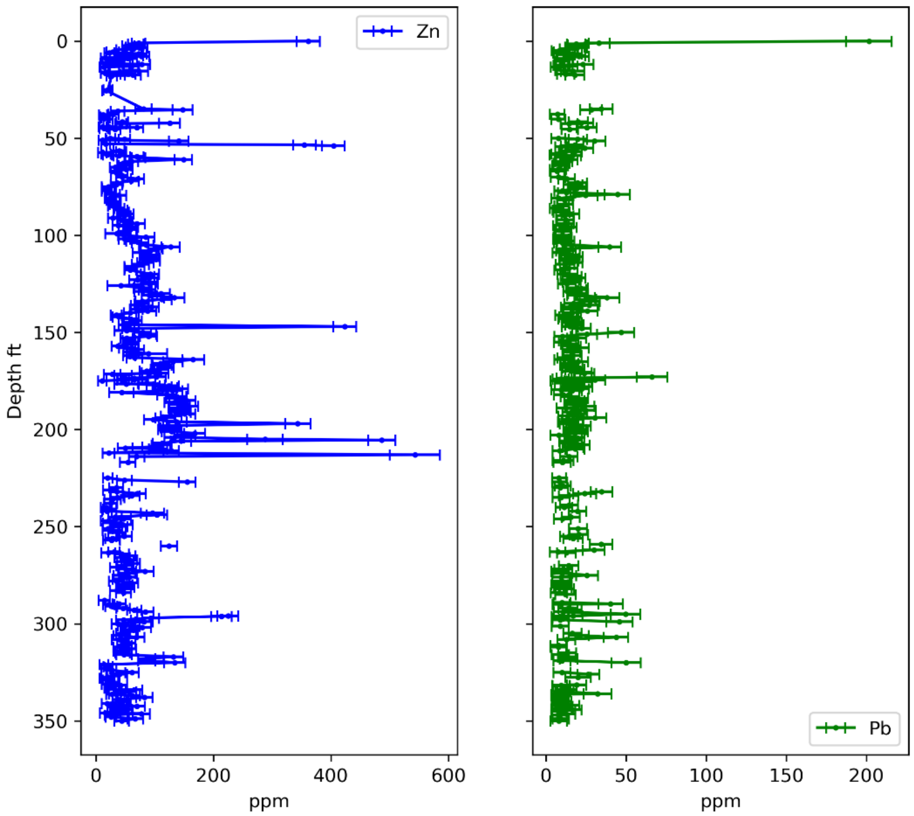
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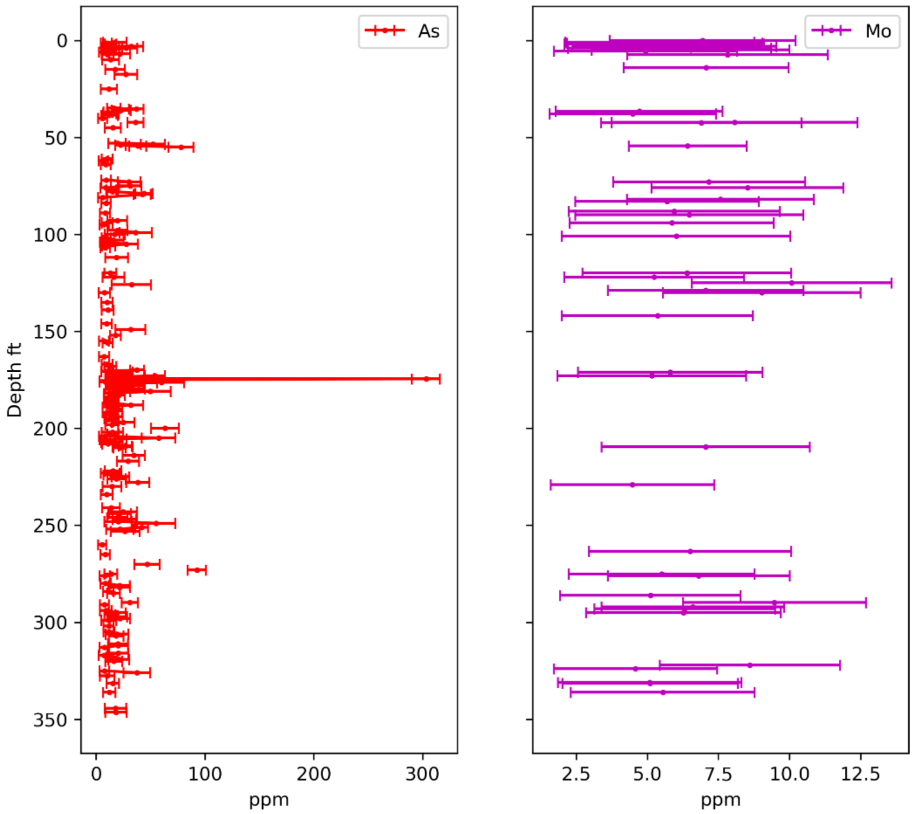
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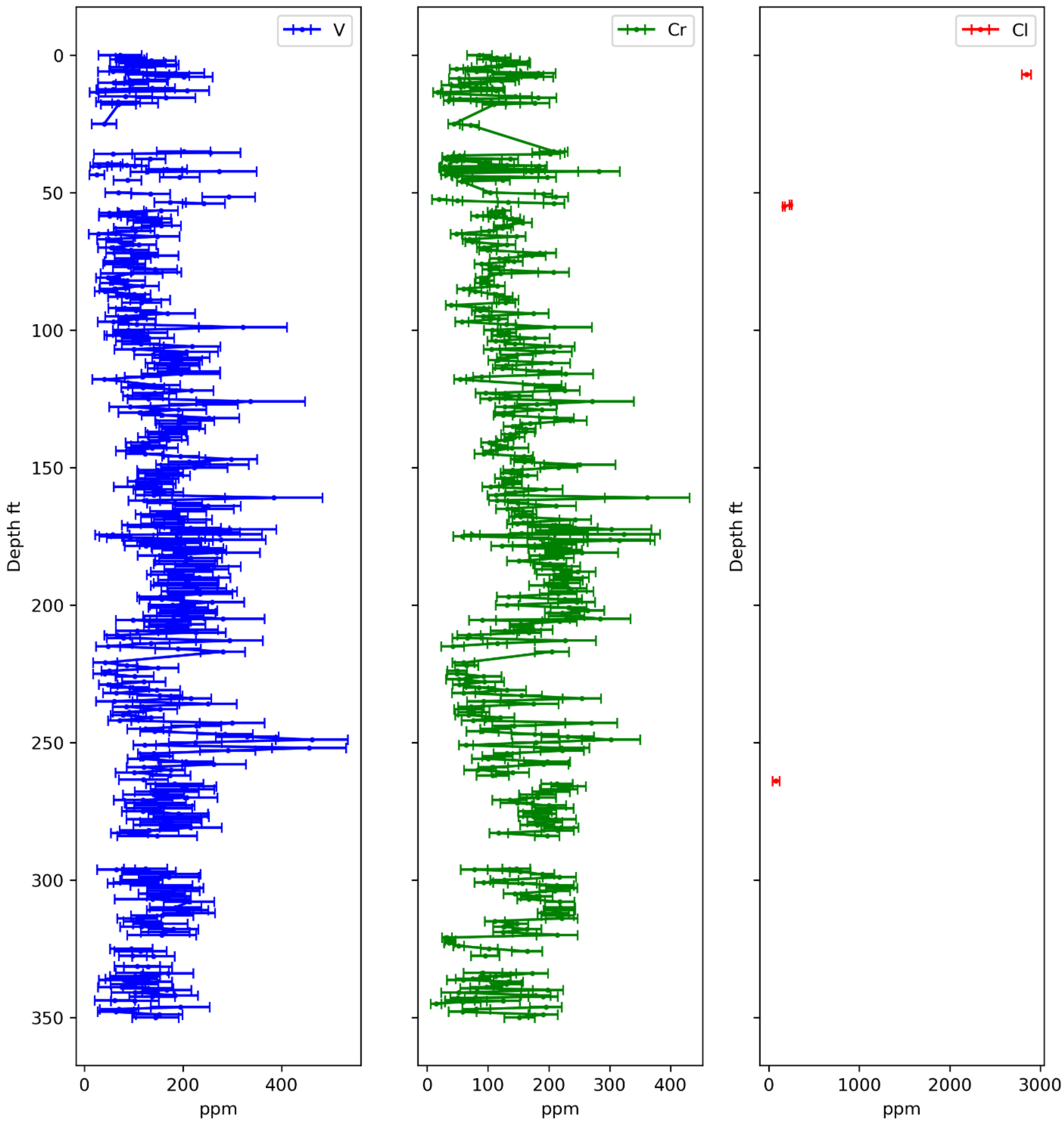
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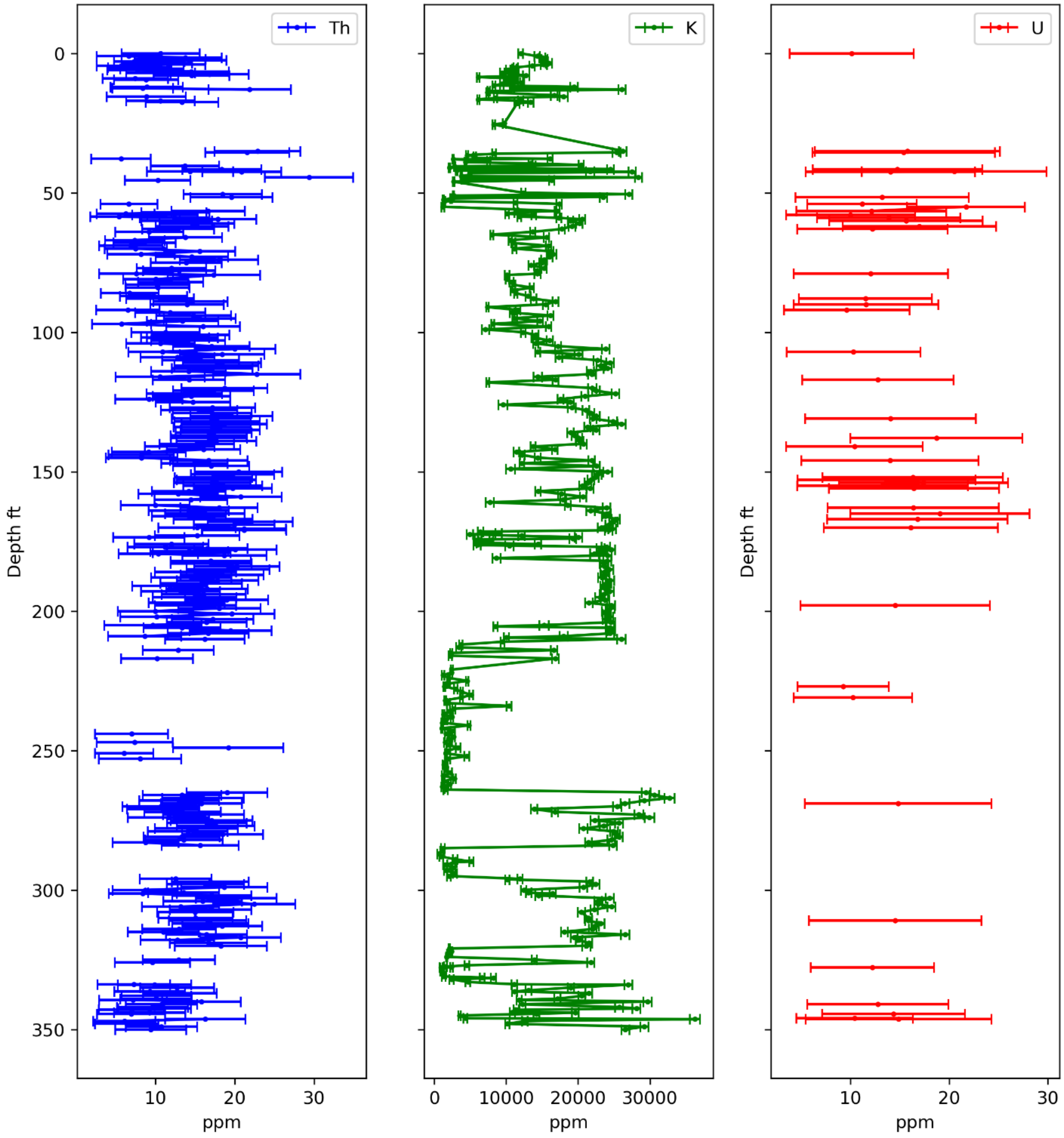
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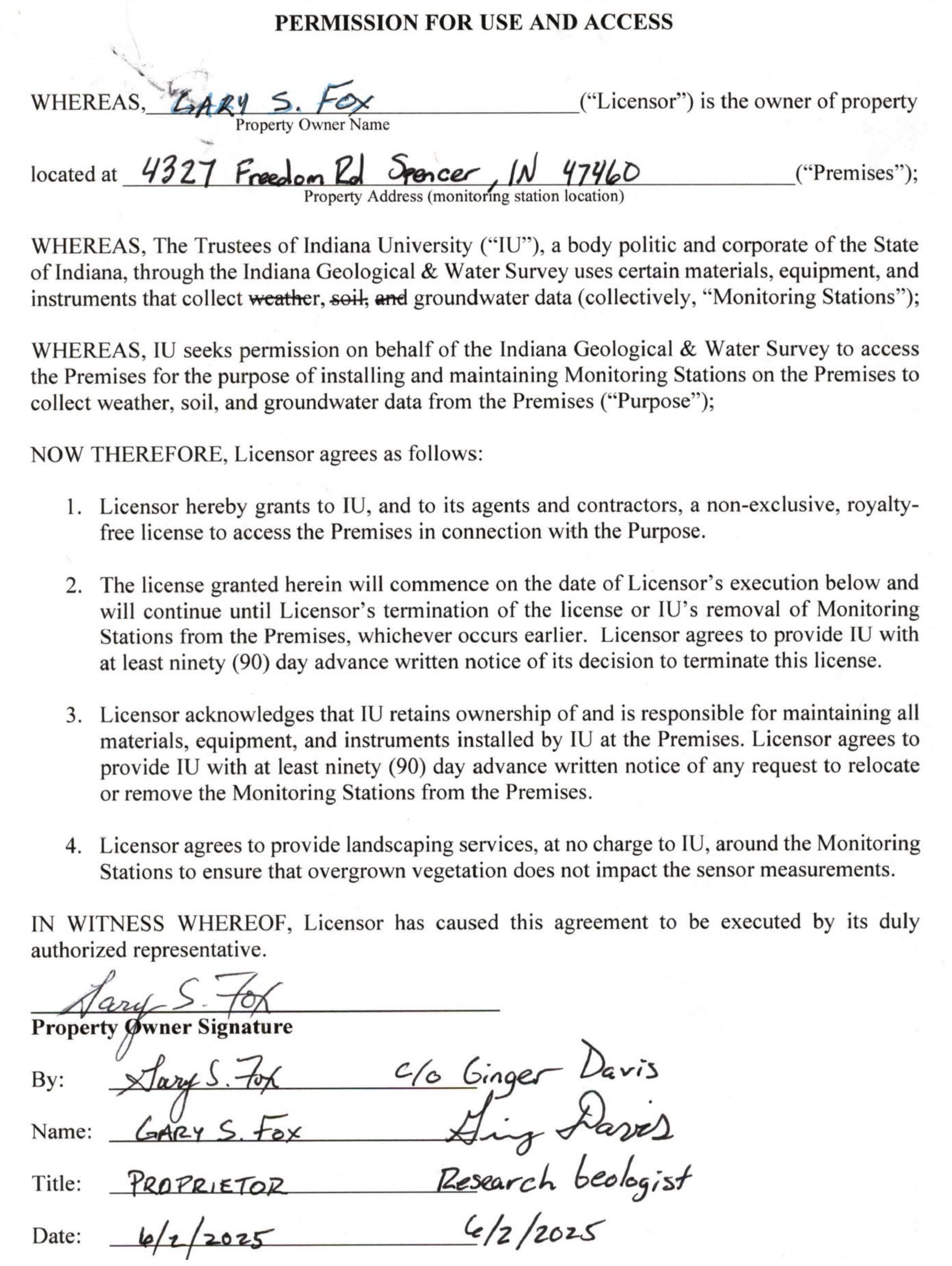
Appendix E. Freedom_E access permission document



PERMISSION FOR USE AND ACCESS

WHEREAS, GARY S. FOX ("Licensor") is the owner of property
Property Owner Name

located at 4327 Freedom Rd Spencer, IN 47460 ("Premises");
Property Address (monitoring station location)

WHEREAS, The Trustees of Indiana University ("IU"), a body politic and corporate of the State of Indiana, through the Indiana Geological & Water Survey uses certain materials, equipment, and instruments that collect ~~weather~~, ~~soil,~~ ~~and~~ groundwater data (collectively, "Monitoring Stations");

WHEREAS, IU seeks permission on behalf of the Indiana Geological & Water Survey to access the Premises for the purpose of installing and maintaining Monitoring Stations on the Premises to collect weather, soil, and groundwater data from the Premises ("Purpose");

NOW THEREFORE, Licensor agrees as follows:

1. Licensor hereby grants to IU, and to its agents and contractors, a non-exclusive, royalty-free license to access the Premises in connection with the Purpose.
2. The license granted herein will commence on the date of Licensor's execution below and will continue until Licensor's termination of the license or IU's removal of Monitoring Stations from the Premises, whichever occurs earlier. Licensor agrees to provide IU with at least ninety (90) day advance written notice of its decision to terminate this license.
3. Licensor acknowledges that IU retains ownership of and is responsible for maintaining all materials, equipment, and instruments installed by IU at the Premises. Licensor agrees to provide IU with at least ninety (90) day advance written notice of any request to relocate or remove the Monitoring Stations from the Premises.
4. Licensor agrees to provide landscaping services, at no charge to IU, around the Monitoring Stations to ensure that overgrown vegetation does not impact the sensor measurements.

IN WITNESS WHEREOF, Licensor has caused this agreement to be executed by its duly authorized representative.

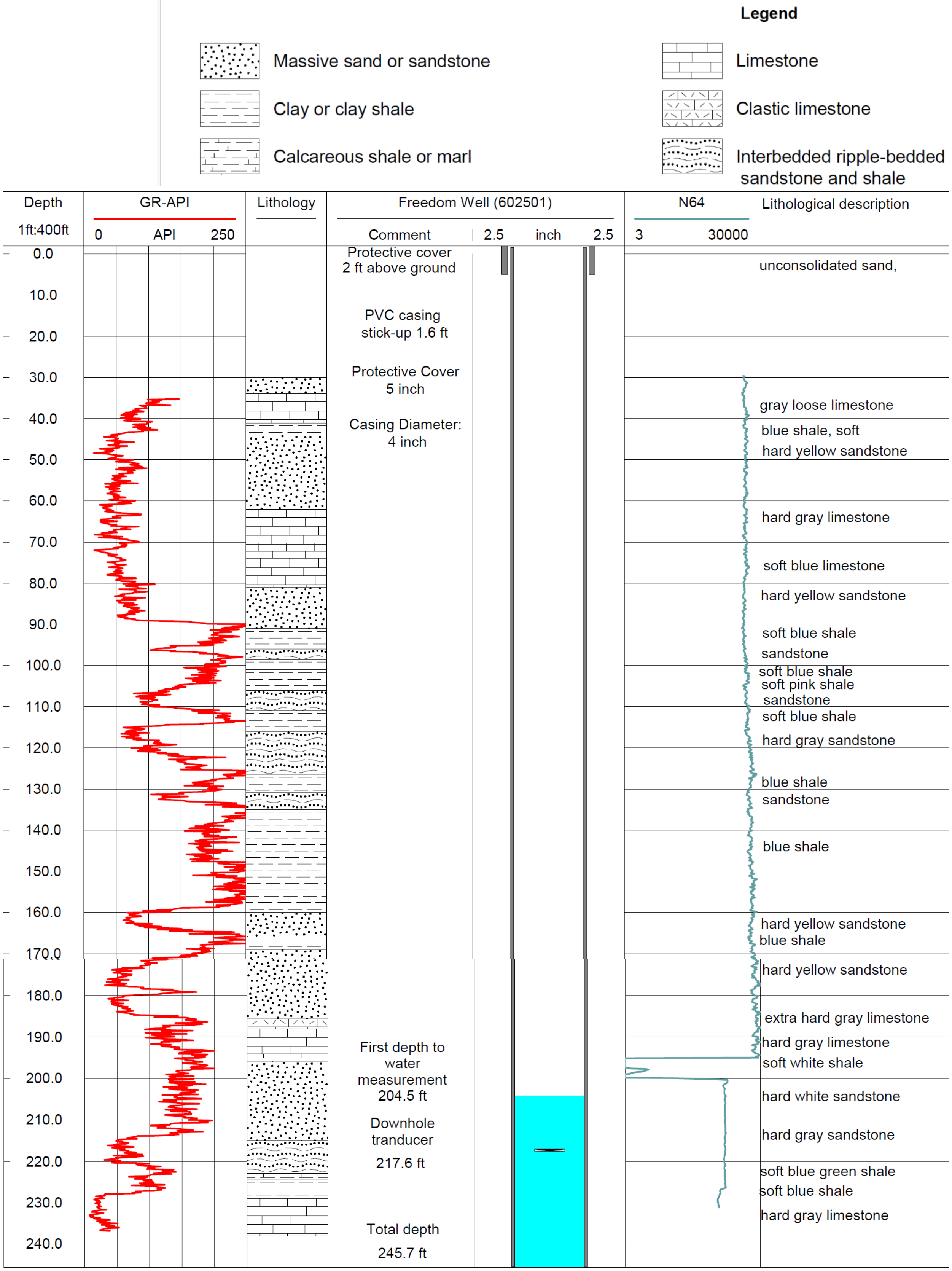
Gary S. Fox
Property Owner Signature

By: Gary S. Fox c/o Ginger Davis
Name: GARY S. FOX Ging Davis
Title: PROPRIETOR Research Geologist
Date: 6/2/2025 6/2/2025

Appendix F. Freedom_E well diagram

INDIANA GEOLOGICAL & WATER SURVEY
INDIANA UNIVERSITY

Site ID: 602501	Date: 08/19/2025
Site Name: Freedom_E	Author: M. Sabaj
Latitude: 39.20497637	Elevation: 717 (NAVD88)
Longitude: -86.84477739	NGWMN Well



Appendix G. Ashley_W access permission document and cooperative agreement

PERMISSION FOR USE AND ACCESS

WHEREAS, DNR/Div Fish & Wildlife ("Licensor") is the owner of property
Property Owner Name

located at: Story Lake PAS ("Premises");
Property Address (well location)

WHEREAS, The Trustees of Indiana University ("IU"), a body politic and corporate of the State of Indiana, through the Indiana Geological & Water Survey uses certain materials, equipment, and instruments that collect groundwater data (collectively, "Monitoring Wells");

WHEREAS, IU seeks permission on behalf of the Indiana Geological & Water Survey to access the Premises for the purpose of installing and maintaining Monitoring Wells on the Premises to collect groundwater data from the Premises ("Purpose");

NOW THEREFORE, Licensor agrees as follows:

1. Licensor hereby grants to IU, and to its agents and contractors, a non-exclusive, royalty-free license to access the Premises in connection with the Purpose.
2. The license granted herein will commence on the date of Licensor's execution below and will continue until Licensor's termination of the license or IU's removal of Monitoring Wells from the Premises, whichever occurs earlier. Licensor agrees to provide IU with at least ninety (90) day advance written notice of its decision to terminate this license.
3. Licensor acknowledges that IU retains ownership of and is responsible for maintaining all materials, equipment, and instruments installed by IU at the Premises. Licensor agrees to provide IU with at least ninety (90) day advance written notice of any request to remove the Monitoring Wells from the Premises.
4. Licensor agrees to provide landscaping services, at no charge to IU, around the Monitoring Wells to ensure that overgrown vegetation does not impact the well.

IN WITNESS WHEREOF, Licensor has caused this agreement to be executed by its duly authorized representative.

Property Owner Signature

By:
Name: Amanda Wuestefeld
Title: Division of Fish & Wildlife Director
Date: 11/4/2024

COOPERATIVE AGREEMENT
For
Well Monitor
AT STORY LAKE PUBLIC ACCESS SITE IN DEKALB COUNTY
between
Indiana Geological and Water Survey and Indiana Department of Natural Resources
Division of Fish and Wildlife

PURPOSE:

Indiana Geological and Water Survey is hereby authorized to construct and maintain a Well Monitor at the Story Lake Public Access Site in Dekalb County, which is owned and operated by the Indiana Department of Natural Resources, Division of Fish and Wildlife.

CONDITIONS:

1) Location must be approved by the Public Access Supervisor (Weston Zurbrugg, Tri-County Fish and Wildlife Area, 8432 N 850 E, Syracuse, IN 46567, 574-526-1736).
2) It shall be the responsibility of the Indiana Geological and Water Survey to maintain the Well Monitor in good condition. The Division of Fish and Wildlife shall not be responsible for any damage, loss, or replacement.
3) The Well Monitor or related users of the well monitor shall not hinder usage of the public to the boat ramp or related parking for boat ramp users
4) This agreement may be terminated at any time by either party or modified through written agreement by the parties. If the Well Monitor agreement is terminated, Indiana Geological and Water Survey agrees to completely remove structures and materials within thirty (30) days of written termination.

SIGNATORIES:

Todd A. Thompson
Indiana Geological and Water Survey
1001 E 10th St
Bloomington, IN 47405

Todd A. Thompson, Director and State Geologist
10/22/2024
Date

Division of Fish and Wildlife
402 W. Washington Street, W273
Indianapolis, IN 46204

Amanda Wuestefeld, Director
11/4/2024
Date

Appendix H. Proposal document for the retrofit of well at the Little Cedar Creek Wildlife Sanctuary

Project Title:
Allen County Replacement Monitoring Well
Repurpose of Existing Well at Little Cedar Creek dedicated Nature Preserve.
Technical Contact:
Ginger Davis
Indiana Geological and Water Survey
Indiana University Bloomington
1001 E. 10th Street
Bloomington, IN 47405-1405
812-855-1364, gindavis@iu.edu
Property Contact:
Evan Hill; Ben Taylor
ACRES Land Trust
1802 Chapman Road; PO Box 665
Huntertown, Indiana 46748
260-637-2273, ehill@acreslandtrust.org, btaylor@acreslandtrust.org
Amount Requested:
$0
Proposed Start Date:
October 10, 2024
Proposed Duration:
10 Years (with the ability to extend)
1-hour continuous monitoring of water levels
Objectives Included in the Proposal:
Retrofit existing well into Monitoring well
Continuous monitoring of well levels

Research abstract or summary:

The goal of the Indian Water Balance Network and its network of monitoring wells is to gather representative monitoring of environmental activities that measure the inflow, flux, and outflow of water within various systems (atmosphere, soil, and aquifer). Developing flow paths that define the movement through the hydrosphere within a variety of physiographic settings helps to define the variations seen across these systems. By including the collection of groundwater and aquifer data at multiple depths, the dynamics of the groundwater system can be assessed. As we evaluate the groundwater in the state, we are poised to find wells that can support a national- and regional-scale dataset for the assessment of important aquifers in Indiana. Our shared goals are to assess the baseline conditions and long-term trends in water levels in these aquifers and continue to drive the data collection. To that end, our monitoring network is expanding and redesigned to assess valuable aquifers. Our current set of deep monitoring wells in the Huntertown area of Allen County have been monitoring since 2008-2009 and have accumulated a nice trend history that allow for statistical analysis of the aquifer characteristics. We are looking for opportunities to replace one of our existing wells with a new well in a similar geologic setting to transfer the accumulated water history. With this replacement well along with 2 other wells we are installing this year, our network will grow to 23 wells in the National

Groundwater Monitoring Network and an additional 21 monitoring wells in our local monitoring network that represent Principal Aquifers of Alluvial and Glacial Origin and the Mississippian Aquifer, along with Secondary Hydrogeologic Regions of Other Aquifers.

Justification of Well Placement

According to the Principal Aquifer well density spreadsheet provided in the NGWMN Tip Sheet on Well Selection Criteria for Water Levels, the recommended number of monitoring wells representing sand and gravel aquifers (glaciated regions) in Indiana is between 10 and 40 wells. Currently, there are 26 wells representing a water-level network in this type of aquifer in the state, with a majority in central Indiana. In northern Indiana, there are 3 NGWMN monitoring wells in Huntertown, Nappanee, and Lake Station. USGS has additional wells in Noble, Whitly County. Groundwater levels in this portion of the state are seeing low values falling in the 10-25 percentile, which is evidence that we need to continue our monitoring to ensure values do not continue to decline. Given that groundwater is a major water supply in this area, there is an immediate need for additional trend monitoring well to improve our understanding of water-resource availability and long-term climate and use trends. Additionally, this area has been identified as an area within Indiana that has a high density of public supply wells. This makes this aquifer of high priority for monitoring purposes.

Unfortunately, recent development in the area is forcing us to abandon one of our long-term deep monitoring wells in this area within the next few months. If we can find a new well to monitor, or drill a new well, and get a 6 month overlap of water level data, we can then transfer the pre-existing water level record to the new well as long as the overlapping records are comparable. Our conversations with state collaborators regarding gap filling in the state also emphasize having continued water level monitoring of the wells in this area is vital to assessing the resource (Randy Maier, Indiana Department of Natural Resources, per. comm. September 2024). Hence, we propose retrofitting the existing well (LCC Well) on the Little Cedar Creek property in Huntertown area of northern Allen County into a monitoring well to replace the existing well (IGWS 021604).

Work Plan

Well retrofitting for LCC well (Task 1)

Task 1a will include removal of existing pumping, cap the distribution line, terminate electrical components, and seal of casing from pitless adaptor. This task requires access to the water in the well and ensure contamination cannot enter the well from adjacent and surface sources. The existing pump in the well is blocking access to the water levels we are interested in monitoring. This task will require us to contract with a Licensed Pump Installer (Licensed by DNR, Division of Water) to attempt to remove the pump. Due to the age of the pump and well, this may be difficult, and success is not guaranteed. The process will involve using a utility truck with winch with or without a tripod to raise the pump, pitless adapter, and drop pipe out of the well. After this is completed, or during the professional may need to dig 3-4 feet below the surface to access the pitless adapter adjacent to the well to seal the distribution pip along with sealing the well casing where the pitless adapter previously attached to the distribution line. We can assure that this dig is in a small area around the well.

Geophysical logging, capacity check, well development, and seal for LCC well (Task 2)

Immediately after removing the pump, we will be able to conduct a geophysical logging (gamma-ray counts) of the well to recover the geologic formations of the well area. This will allow us to make a well log for this well using State Form 35680. Our logging equipment picks up background radiation from the geologic materials and allows us to understand the clay components in the formations. This is a non-invasive assessment with no risk to the well or surrounding environment.

Since this in an old well used for domestic supply, the screen may have become fouled and no longer in good connection with the aquifer. To determine the wells capacity to record water levels freely, we will conduct a slug test and start to monitor the water levels immediately. The slug test is a standard process. To do this we use pressure slug (if there are no seal gaps) or a solid slug that changes the water level and monitor with our sensor to see how water levels respond and recover. This will give us a good indication of the status of the well and screen. We plan to conduct this test immediately after removal of the pump.

If at this point, we determine that the well is fouled or poorly connected to the aquifer. We will conduct a well development and cleaning of the well to try and recover the screen. This involves agitating the well screen with pressurized air and then pumping of the water to try and remove fines from the well screen. Recognizing standard erosion control practices, we will direct water to a location where water can reabsorb into the ground.

Regaining full access to the aquifer, determined by monitoring over a 2–3-week period is the goal. If the slug test and well development for the LLC well is unsuccessful, arrangements will be made to remove all equipment and return the well (less pump and pitless adapter) to its original condition. At this pint we can assist and guide you towards the proper abandonment and sealing procedure for a well of this age.

Regardless of the status of the screen, waterproof caps will be placed on the top of the well to ensure security of the well from pest or other sources of potential contamination of the aquifer.

Initiate monitoring and create web services for LCC well (Task 3)

After well assessment period, if the well is usable for monitoring, a survey of the well casing elevations, and a pressure transducer will be secured with a monitoring cap at the LLC well to initiate long-term monitoring. Initial water-level monitoring data, lithology data, GPS survey data, and well completion diagrams will be compiled to populate web services for the new monitoring well.

Continuous Monitoring of the well (Task 4)

With a functional well a minimum of 3 times per year our team will come onsite to download data from the pressure transducer, take a hand measurement for QAQC purposes, and preform any necessary maintenance to the well including but not limited to well development, camera scoping, agitation of screen, and pumping of the water to ensure aquifer connection.

Number of people to be involved:

The on-site crew for the installation will be 3-5 people, up to two pump installers (to remove pump) and 2-3 geologist or support staff. Once a monitoring well is installed a 2 or 3-person crew will come to the site 3 to 4 times per year to monitor and maintain the well.

Temporal extent: period of data collection

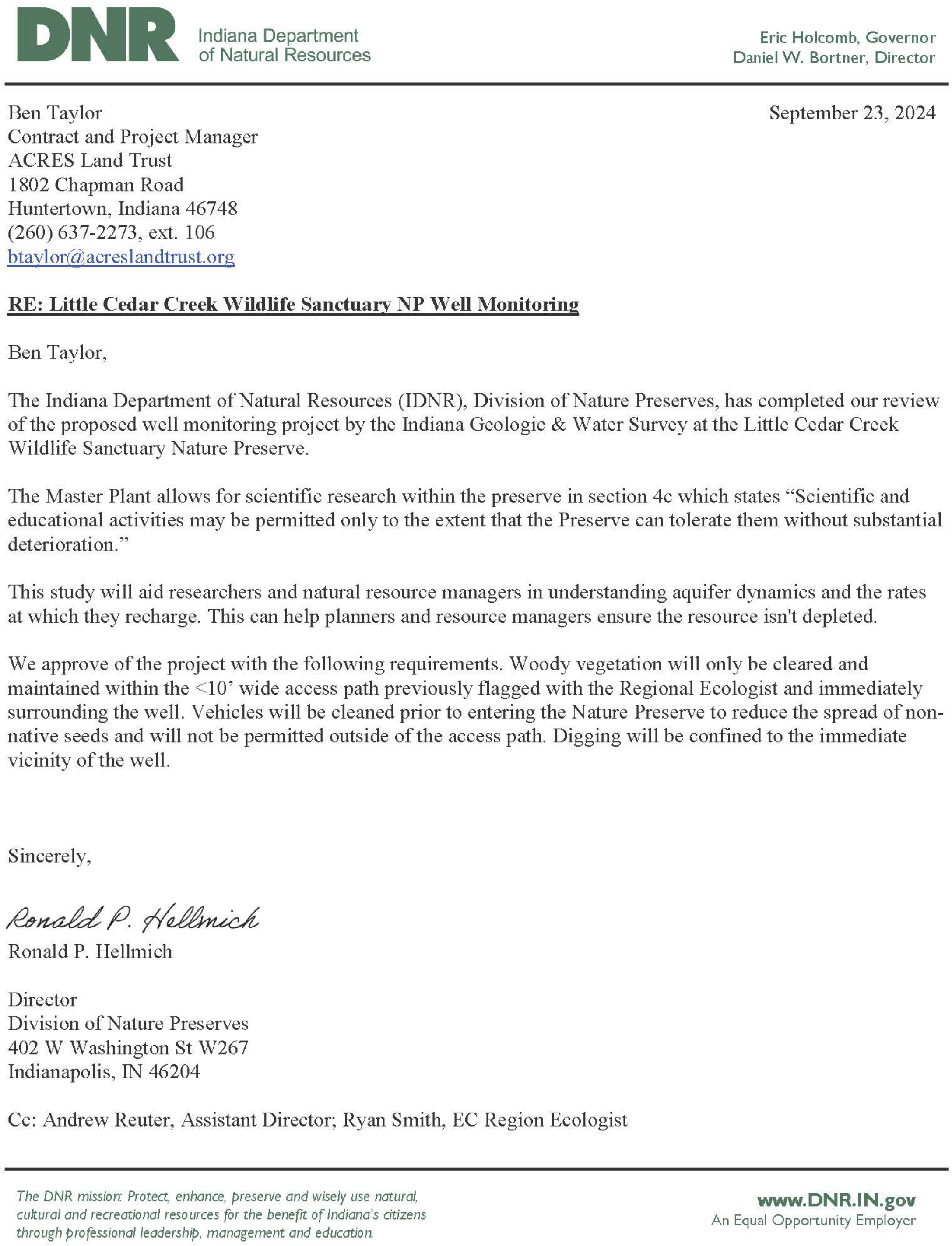
The initial pump pull, well tests, and well development will take place over a 7-10 business day period in late September or early October. We would collect the data to assess the well over a one-month period in October 2023. At this point, if the well proves to be capable, we would then like to keep the well in service for at least 10 years (January 2035), or up to 100 years (2125) if acceptable. We will be collecting hourly water level measurements while the well is in the network. The best monitoring wells are the ones we can keep an active eye on the system for decades. Wells do require maintenance and cleaning to keep in good working condition and may require more intense service after 30 years. Wells can be maintained for accurate measurements for a limited duration dependent on the water quality, material within the aquifer, and quality of the well installation, but we intend to maintain the well while in the network. If at any point it is deemed that the well is no longer able to measure the aquifer levels accurately, or the landowner wishes to terminate the agreement, the well would need to be plugged according to Indiana Administrative Code, 312 IAC 13 and buried. We would be willing to assist with this operation to help with the costs for this procedure.

Associated Permits

Upon completion a well log will be produced and supplied to DNR Division of Water for their water well record database. A copy of the form that is required to be completed upon completion of the well can be found here: State Form 35680.

A use agreement needs to be signed by ACRES Land Trust and is attached here.

Appendix I. Approval and site stipulations for conservation easement access at FortWayne_N4



DNR Indiana Department of Natural Resources

Eric Holcomb, Governor
Daniel W. Bortner, Director

September 23, 2024

Ben Taylor
Contract and Project Manager
ACRES Land Trust
1802 Chapman Road
Huntertown, Indiana 46748
(260) 637-2273, ext. 106
btaylor@acreslandtrust.org

RE: Little Cedar Creek Wildlife Sanctuary NP Well Monitoring

Ben Taylor,

The Indiana Department of Natural Resources (IDNR), Division of Nature Preserves, has completed our review of the proposed well monitoring project by the Indiana Geologic & Water Survey at the Little Cedar Creek Wildlife Sanctuary Nature Preserve.

The Master Plant allows for scientific research within the preserve in section 4c which states “Scientific and educational activities may be permitted only to the extent that the Preserve can tolerate them without substantial deterioration.”

This study will aid researchers and natural resource managers in understanding aquifer dynamics and the rates at which they recharge. This can help planners and resource managers ensure the resource isn't depleted.

We approve of the project with the following requirements. Woody vegetation will only be cleared and maintained within the <10’ wide access path previously flagged with the Regional Ecologist and immediately surrounding the well. Vehicles will be cleaned prior to entering the Nature Preserve to reduce the spread of non-native seeds and will not be permitted outside of the access path. Digging will be confined to the immediate vicinity of the well.

Sincerely,

Ronald P. Hellmich
Ronald P. Hellmich

Director
Division of Nature Preserves
402 W Washington St W267
Indianapolis, IN 46204

Cc: Andrew Reuter, Assistant Director; Ryan Smith, EC Region Ecologist

The DNR mission: Protect, enhance, preserve and wisely use natural, cultural and recreational resources for the benefit of Indiana's citizens through professional leadership, management and education.

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ACRES
LANDTRUST

EMERGENCY FIELD CONTACT

NAME Ginger Davis

PHONE 812-855-1364

PERMISSION TO ACCESS RESTRICTED AREA

Ginger Davis IS GRANTED ACCESS

TO Properties shown in Exhibit A.

FROM ACRES, Inc.

FOR THE PURPOSE OF scientific research

THIS AUTHORIZATION IS EFFECTIVE 9/30/2024 AND EXPIRES* 1/30/2025

BY Ben Taylor Benjamin Taylor Digitally signed by Benjamin Taylor
Date: 2024.09.27 08:07:55 -04'00'

**Access permission may be extended annually through mutual written consent.*

Display one copy of this letter on the dashboard of the driver's side of the vehicle and carry a copy on your person.

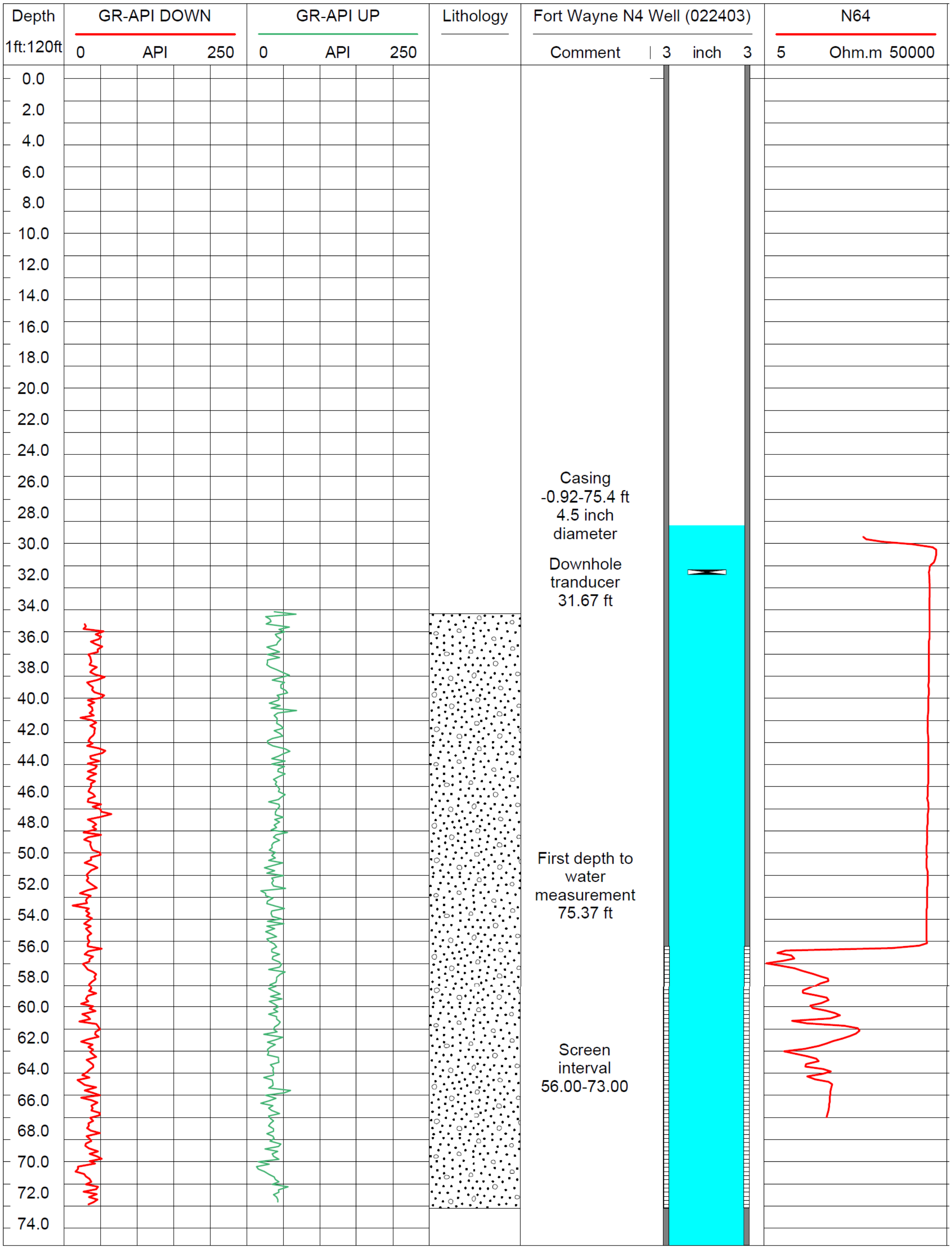
Appendix J. FortWayne_N4 well diagram

INDIANA GEOLOGICAL & WATER SURVEY
INDIANA UNIVERSITY

Site ID: 022403	Date: 10/17/2024
Site Name: FortWayne_N4	Authors: M. Sabaj
Latitude: 41.25879	Elevation: 839.3 ft
Longitude: -85.14291	NGWMN well

Legend

▨ Gravel or conglomerate



Casing
-0.92-75.4 ft
4.5 inch
diameter

Downhole
tranducer
31.67 ft

First depth to
water
measurement
75.37 ft

Screen
interval
56.00-73.00

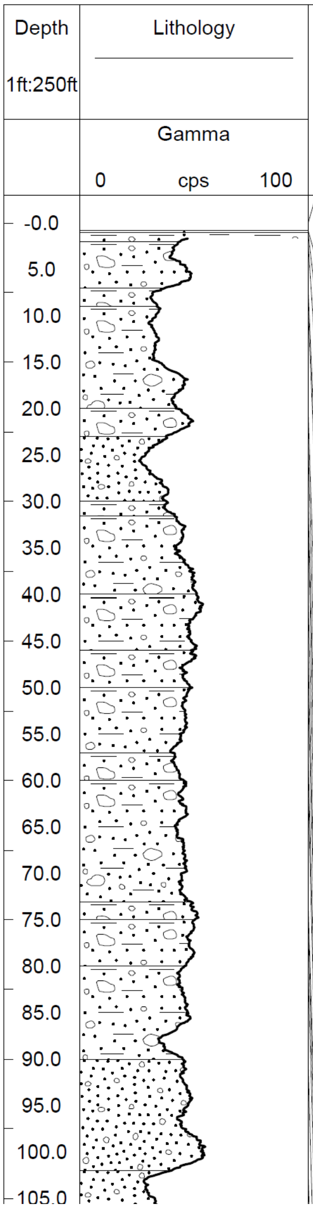
Appendix K. Ashley_W lithologic log and well construction document

INDIANA GEOLOGICAL & WATER SURVEY
INDIANA UNIVERSITY

Site ID: 172404	Date:11/14/2024
Site Name: Ashley_W.	Author: G. Davis
Latitude: 41.51546	Elevation: 947.84 (LIDAR)
Longitude: -85.135095	NGWMN Well

Legend

▨	Gravel or conglomerate 1	▨	Massive sand or sandstone
▨	Gravel or conglomerate 2	▨	Silt, siltstone or silty shale
▨	Till or diamicton	▨	Clay or clay shale



Description

(0-0.8') Loam (Fm) + Fill (SG), loam organics over sandy gravel fill material, very dark grayish brown (10YR3/2), moist, oxidized-leached, no reaction, stiff consistency, sharp lower contact, organics, roots, grass

(0.8-1') Loam (Dmm), very dark grayish brown to very dark brown(10YR3/2-10YR 2/2), moist, non calcareous, weathered and oxidized, diamicton parent material

(1-2') Sandy loam (Dmm), dark grayish brown (10YR 4/2) with dark yellowish brown (10YR 4/4) at the top, moist, oxidized-leached, mottled, sharp lower contact, Bw/Bt horizon of weathered till, granular to block ped structure, Magnesium along rootlets.

(2-7')loam (Dmm) with pebbles, dark grayish brown (10YR 4/2) to dark gray (10RY 4/1), moist, oxidized- unleached, moderate reaction, mottling, pebbles of dark gray shale/siltstone, gray-brown limestone, gray dolostone, and possibly sandstone. Some limestone sees bioclastics included with greenish limestone appearing, minor greenstones and granite.

(7-9') sandy loam till (Dmm) no recovery, gamma interpreted

(9-20') loam (Dmm)with pebbles, dark gray (10YR 4/1) to dark grayish brown (10YR 4/2), moist, calcareous loam diamicton with pebbles, pebbles collected in core are of composition: gray bioclastic limestone, dark brown limestone, dark gray limestone, gray/green/brown dolostone, brown bedded sandstone, intrusive (possibly basalt) and granite greenstones, quartz; interbedded with saturated sandy diamicton, but only recovery is gravel from those intervals; only recovered 2 ft from 9' to 20'.

(20-23') sandy loam to loam (Dmm), dark gray (10YR 4/1), moist, calcareous clasts composed of dark gray limestone, brown reddish limestone, brown limestone brown-tan dolostone, sandstone (quartz) with greenish tint, dark gray shale, and possibly jasper

(23-30') sand and gravel (SG), no recovery, driller informed pushed through sandy cobble, gamma interpreted

(30-31.5') loam (Dmm) with pebbles, dark gray (10YR 4/1), moist, calcareous pebbly diamicton, clasts composed of brown limestone with fossil imprints, tan dolostone, gray dolostone, gray limestone, greenstone.

(31.5-40') loam till (Dmm), no recovery, gamma interpreted

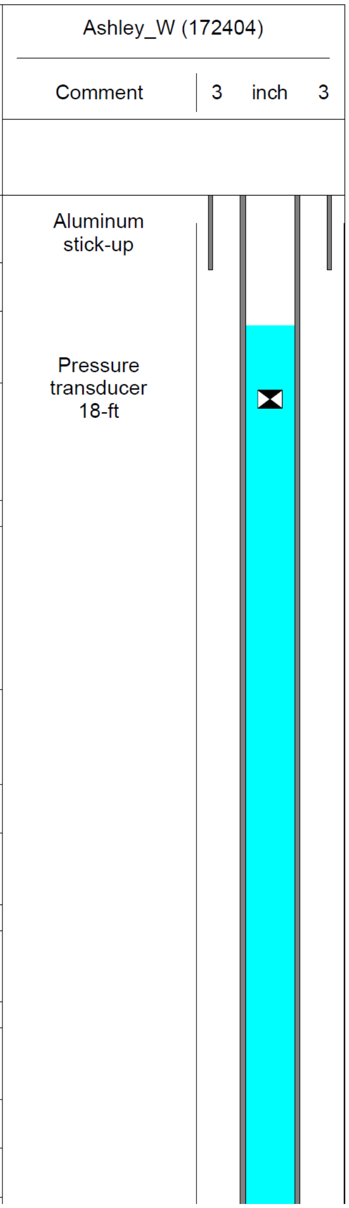
(40-46') loam (Dmm) with pebbles, dark gray (10YR 4/1), moist, calcareous pebbly diamicton, clasts composed of dark brown limestone , tan dolostone, dark gray limestone, greenstone, diorite, jasper, red granite, brown quartz sandstone.

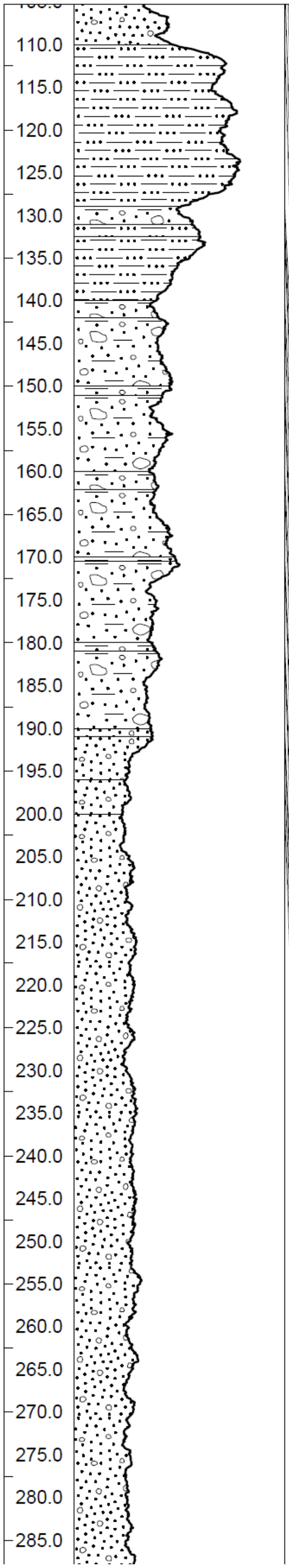
(46-50') loam till (Dmm), no recovery, gamma interpreted

(50-57') loam (Dmm) with pebbles, dark gray (10YR 4/1), moist, calcareous clasts composed of tan dolostone, dark gray limestone, dark brown limestone, greenstone (crystalline), red granite, dark gray shale/siltstone

(57-60') interbedded sand and gravel(SG) with loam till (Dmm), no recovery, driller and gamma interpreted glacial fluvial

(60-73') interbedded sand and gravel(SG) with loam till (Dmm), no recovery, driller and gamma interpreted glacial fluvial





(73-75') loam (Dmm) with pebbles, dark gray (10YR 4/1), moist, calcareous pebbly diamicton, clasts composed of brown limestone , tan dolostone, brown dolostone.

(75-80') interbedded sand and gravel(SG) with loam till (Dmm), no recovery, driller and gamma interpreted glacial fluvial

(80-90') interbedded sand and gravel(SG) with loam till (Dmm), minor (0.5') recovery showing loam (Dmm), dark gray (10YR 4/1), moist, calcareous matrix of pebbly diamicton, clasts composed of brown limestone , tan dolostone, brown dolostone., driller and gamma interpreted till

(90-102') sand and gravel (SG), minor (0.5') recovery, clasts composed of dark shale fragments, gray black limestone, red granite, brown dolostone, chert, driller and gamma interpreted

(102-110') sand and gravel (SG), minor (0.5') recovery, clasts composed of dark shale fragments, gray black limestone, red granite, brown dolostone, chert, driller and gamma interpreted

(110-129') silt loam to silty clay loam (Fm), dark gray (2.5Y 4/1), glaciolacustrine, dropstones near top and bottom, fining upward (clay rich at top more silty at bottom), weakly laminated at 126'.

(129-131') loam (Dmm) with pebbles, dark gray (2.5Y 4/1),moist, clasts composed of black shale, quartz, jasper, red granite.

(131-132.5') silt loam to sandy silt loam (Fl), laminated, dark gray (2.5Y 4/1), fine sands, some granules at base, moist, glaciolacustrine.

(132.5-140') sandy silt loam (Fl), no recovery, gamma interpreted

(140-142') sandy loam (Dmm), dark gray (2.5Y 4/1), moist, calcareous matric, clasts composed of black shale, white sandstone, gray limestone, brown limestone, green limestone, red granite, quartz, porphyry, dark red granite, dolostone.

(142-150') sandy loam (Dmm), no recovery, gamma interpreted

(150-151') sandy loam (Dmm), dark gray (2.5Y 4/1), moist, calcareous matric, clasts composed of brown limestone, red granite, dolostone.

(151-160') sandy loam (Dmm), no recovery, gamma interpreted

(160-162') sand and gravel (SG) with interbedded loam (Dmm), dark gray (2.5Y 4/1)(diamicton), glaciofluvial, clasts composed of brown limestone, dolostone.

(162-170') sand and gravel (SG) with interbedded loam (Dmm), no recovery, gamma interpreted

(170-170.5') loam (Dmm), dark gray (2.5Y 4/1)(diamicton), glaciofluvial, clasts composed of brown limestone, dolostone.

(170.5-180') sand and gravel (SG) with interbedded loam (Dmm), no recovery, gamma interpreted

(180-181') sand and gravel (SG) with interbedded loam (Dmm), dark gray (2.5Y 4/1)(diamicton), glaciofluvial, 1' sand and gravel recovery and 0.5' till recovery.

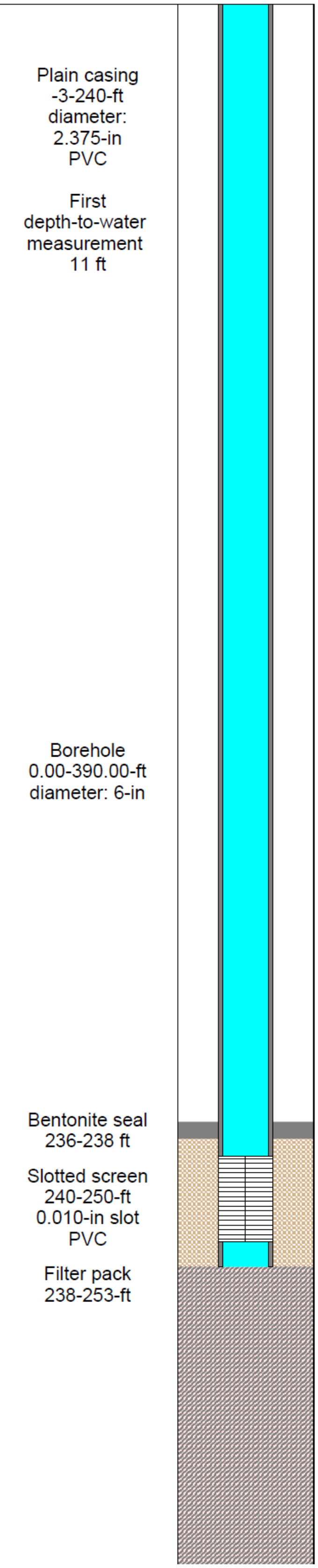
(181-190') sand and gravel (SG) with interbedded loam (Dmm), no recovery, gamma interpreted

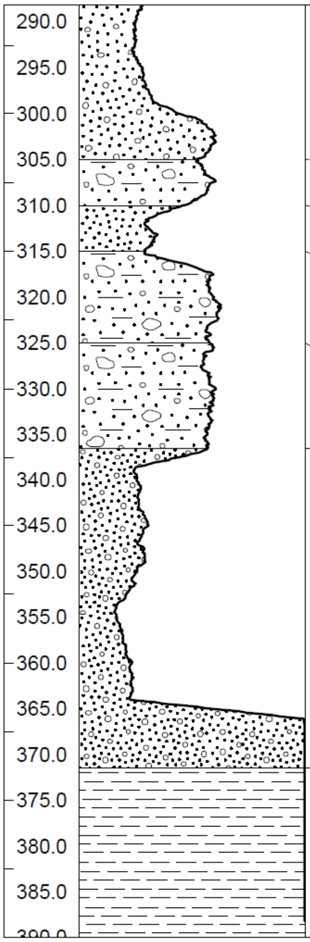
(190-191') sand and gravel (SG), glaciofluvial, course sand to gravel

(191-196') sand and gravel (SG), glaciofluvial, no recovery, gamma interpreted

(196-200') sand and gravel (SG), large pieces returned, likely cut through boulder, pieces are limestone, greenstone(tan chert), and minor amount of igneous

(200-305') sand and gravel (SG), glaciofluvial, no recovery, gamma interpreted, driller noted that at 285' fine sand layer lost fluid then pressure buid indicating heaving sands.





(305-310) loam (Dmm) with granules, dark brown (10YR 3/3), composition greenstone, recover of 0.5' gamma interpreted the rest.

(310-315) fine sand(S), no recovery, driller felt tug of fine sand and gamma log interpreted

(315-325) clay loam (Dmm), dark brown (7.5YR 3/2), hard dense till pebbles composed of red siltstone, characteririte, some limestone, greenstone, sand fills fractures which are common and diagonal to core direction, wood fragments were found within the till.

(325-336.5)loam (Dmm), dark brown (7.5YR 3/2), hard dense loam diamicton pebbles composed of limestone, greenstone (when dry turns gray), siltstone, quartz fragments.

(336.5-371.5) sand and gravel, no recovery, driller notes no loss of fluids so may be "dirty", gamma/driller interpreted

(371.5-390) Bioturbated lenticular-bedded black shale (Fslbz), greenish black (Glay 1 2.5/10Y) saprolite down to 380', sparkle luster when lighted, large quartz cast (possibly from above sg), bioturbated gray shale with interbedded dark greenish gray (Glay 1 4/5GY), petroleum odor at first volatized after time.

Drill cuttings
backfill