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MEMORANDUM

January 5, 2022

The Honorable Kim Reynolds
State Capitol
1007 East Grand Ave.
Des Moines, IA 50319

Mr. Charlie Smithson
Secretary of the Senate
State Capitol Building
Des Moines IA 50319

Ms. Meghan Nelson
Chief Clerk of the House
State Capitol Building
Des Moines IA 50319

Re: State Geologist Annual Report

Dear Governor Reynolds and Members of the Iowa General Assembly:

Pursuant to the 2018 Iowa Acts, Ch. 1023.15**,** enclosed is the State Geologist Annual Report for 2020-2021.

If you have any questions or need more information, please don't hesitate to contact me.

Sincerely,

Mark J. Braun

\Box Sync\Board of Regents Shared\BF\Legislative\2022 session\Reports\

Attachments
cc: Brendan Beeter
Legislative Liaisons
Legislative Log

IOWA

the IGS Geode

ACTIVITIES OF THE IOWA GEOLOGICAL SURVEY, 2020–21

IN THIS ISSUE:

MAPPING SINKHOLES AND LANDSCAPES

CARBON SEQUESTRATION

ESCAPE TO LEDGES

AND MORE

IOWA
GEOLOGICAL
SURVEY

The IGS Geode

Activities of the
Iowa Geological Survey
2020–21

ON THE COVER: Ledges, one of Iowa's oldest state parks, offers beauty and interesting geologic features for visitors.

THE IGS MISSION: To collect, reposit, and interpret geologic and hydrogeologic data; to conduct foundational research; and to provide Iowans with the knowledge needed to effectively manage our natural resources for long-term sustainability and economic development.

THE IGS VISION: To be a nationally recognized leader in geologic and hydrogeologic sciences, building upon our rich scientific heritage and serving Iowans through research, education, and outreach.

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Contents

From the State Geologist

WITH THIS ISSUE of *The IGS Geode*, we're celebrating another outstanding year of research, service, and education dedicated to the state of Iowa and our collaborative partners. While it's hard to ignore the COVID-sized elephant in the room that always seemed to get in the way, the Iowa Geological Survey (IGS) continued a remarkable run of success, which we are pleased to highlight in this issue.

IGS geologists and hydrogeologists were able to find a way to get field and office work done on time and within budget, meet project deadlines, conduct outstanding research, and acquire and collaborate on new and innovative projects. You would think that the pace of the IGS might have slowed during the past year, but like a good field geologist, the IGS staff adapted to conditions beyond our control and found a way to get the job done.

A highlight of this past year was hiring a new bedrock geologist, Alyssa Bancroft, to join our IGS team. This was actually a homecoming for Alyssa because she did postdoctoral research with Brad Cramer in the University of Iowa Department of Earth and Environmental Sciences (EES) a few years ago. Alyssa's main duties will be to conduct bedrock geologic mapping as part of the U.S. Geological Survey (USGS)-funded STATEMAP program and to assist with other bedrock-related issues faced by the state. It is important to note that Alyssa's hiring would not have been possible without matching contributions from our friends in the EES department and new mapping initiatives funded by the USGS. We are so pleased that Alyssa stepped right into bedrock mapping in eastern Iowa and even volunteered to investigate Ledge State Park for this issue of the *Geode* (see page 18). Welcome aboard, Alyssa!

The IGS team: (back row, l-r): Stephanie Tassier-Surine, Sophie Pierce, Rosemary Tiwari, and Alyssa Bancroft; (front row, l-r): Phil Kerr, Matthew Streeter, Ryan Clark, Keith Schilling, Jason Vogelgesang, Greg Brennan, Rick Langel, and Mike Gannon

A feature story for this issue focuses on a project funded by the Iowa Department of Transportation (IDOT) to update sinkhole locations and karst susceptibility in north-central Iowa (see page 14). This ambitious project involved a number of IGS staff, including Stephanie Tassier-Surine, Ryan Clark, Phil Kerr, and Jason Vogelgesang, and included help from the Iowa Department of Natural Resources' (IDNR) Calvin Wolter, as well as numerous student workers. Beyond simply mapping new sinkhole locations, the project team investigated factors that affect the formation of sinkholes and used geophysics to take a peek inside the sinkhole system. Altogether, this project illustrated the value of teamwork to solve a complex geologic issue, providing results that were both enlightening and hugely practical for the IDOT and ultimately all Iowans.

The IGS continued to partner with the IDNR on several issues of interest to local partners as well as statewide initiatives. In addition to geologic logging and maintaining our core and chip repository (work led by Rick Langel, see page 16), Mike Gannon and Greg Brennan conducted a hydrogeologic investigation and groundwater modeling project to investigate potential water depletion near a state-owned lake in western Iowa (see page 5). Ryan Clark also assisted a homeowner with a sinkhole formation in Cedar Rapids (see page 4). Ryan has also been instrumental in leading Iowa's partnership with regional carbon capture and sequestration entities — a potentially significant opportunity that could bear fruit in the coming years (see page 8). My article on groundwater recharge, though not conducted at the request of IDNR, certainly benefits state agencies charged with water resource planning and drought mitigation (see page 11).

In other articles, the IGS continued to partner with state and local agencies on water-quality conservation practice monitoring and efforts; Matthew Streeter and Sophie Pierce report on monitoring conducted at alternative tile intakes and restored oxbows, respectively (see pages 6 and 7). Phil Kerr finished mapping in Benton County and continues his ongoing interest in Iowa's landscape development (see page 13). In his article, Phil finally explains why the steep hills near Highway 30 in Tama County give way to flat and rolling terrain in Benton County — I know that this has vexed travelers along this highway for many years. Greg Brennan describes a new weapon in our geophysics arsenal, passive seismic, which has been used successfully in our Benton County mapping efforts (see page 12).

As you read this issue of *The IGS Geode*, please take note of the breadth of knowledge and variety of activities demonstrated by a group of just 11 geologists during a pandemic. As a father I know what it is like to be proud, but I have to say that I couldn't be more proud of this group and their willingness to persevere and produce high-quality results during a time of challenging circumstances. I'm delighted to acknowledge this in my short message and I hope you'll share with my appreciation of a job well done.

Keith Schilling

KEITH SCHILLING
State Geologist

Partnering with the Iowa Department of Natural Resources

The Iowa Geological Survey works collaboratively with the Iowa Department of Natural Resources (IDNR) on many issues related to Iowa's water and natural resources. The IGS shares data and expertise across several different platforms, including information related to well records, geologic samples, pump test results, and other geospatial data. During the 2020–21 fiscal year, the IGS provided the following services to the IDNR:

- Updated GeoSam with records from over 740 wells. Fifteen of the records were specifically for the IDNR's Water Use and Public Water Supply programs, and 41 were for the IDNR's Animal Feeding Operation program
- Provided a lithologic strip log for a water well that was 1,225 feet deep in Fredericksburg
- Analyzed 12 pump tests and entered them into the IGS PumpTest database for IDNR access
- Evaluated shallow groundwater levels on a monthly basis for inclusion in the IDNR's Drought Summary update

Not in My Backyard: Investigating a Sinkhole in Cedar Rapids

by Ryan Clark

SINKHOLES CAN OCCUR in many places throughout Iowa. Typically, they develop where limestone bedrock is close to the land surface. The formation of these natural hazards can be accelerated by water diversion features.

So, it was not too surprising when a concerned homeowner in Cedar Rapids contacted the Iowa Department of Natural Resources (IDNR) about a potential sinkhole opening up in their backyard. In December 2020, IGS geologist Ryan Clark visited the site along with IDNR staff to assess this feature of concern.

Located in a manmade stormwater drainage ditch behind the neighborhood, the feature was definitely a sinkhole (Fig. 1). Upon visual inspection, it was apparent that much of the overlying sediment had been removed, presumably through the hole observed at the base. Although no bedrock was exposed, well data and geologic map information confirmed that the limestone bedrock is relatively shallow in this area. This sinkhole is likely related to a crevice in the limestone into which surface water can carry unconsolidated sediment down into the subsurface, rather than an open void in the underlying bedrock that has collapsed, as is often the fear of many homeowners.

The experts on-site communicated this to the concerned homeowners and suggested that they monitor the situation and report any future development of the sinkhole to the city engineer's office.

FIGURE 1. Visual inspection of the sinkhole revealed the point where water (and sediment) likely escaped into the subsurface.

Black Hawk Lake Groundwater Modeling Project

by Mike Gannon and Greg Brennan

BLACK HAWK LAKE, located in central Sac County, is the southernmost natural lake in Iowa. This 922-acre lake faces numerous water-quality issues and was recently targeted for improvement to restore water clarity and quality. The Iowa Department of Natural Resources (IDNR) proposed hydraulic dredging of naturally deposited sediments in the lake as one potential mitigation strategy. Such activity requires a disposal plan for the dredge material. One option would be to place the material in an abandoned sand and gravel quarry owned by Hallett Construction about two miles south of Black Hawk Lake (Fig. 1).

Based on the mass balance equations in the model, filling the former Hallett Quarry with dredge material would reduce the overall quarry recharge to the West Central Iowa Rural Water (WCIRW) wells from 49 percent to 32 percent following disposal, a reduction of 17 percent. Based on the model results, some of the recharge from the former Hallett Quarry would be replaced by recharge from other nearby quarries.

Figures 2A and 2B show shows how particle tracking in the model allowed us to look at the groundwater flow lines and track the sources of groundwater recharge. The other sources of recharge (post-dredge disposal) are located farther away from the WCIRW wells than the former Hallett Quarry. This would require the recharge water to travel a greater distance to reach the WCIRW wells and would therefore increase the drawdown at each well by approximately 15 percent. This additional drawdown would not impact current water usage from the WCIRW wells. The IGS is currently working with WCIRW to evaluate the future expansion of this wellfield using the calibrated groundwater flow model.

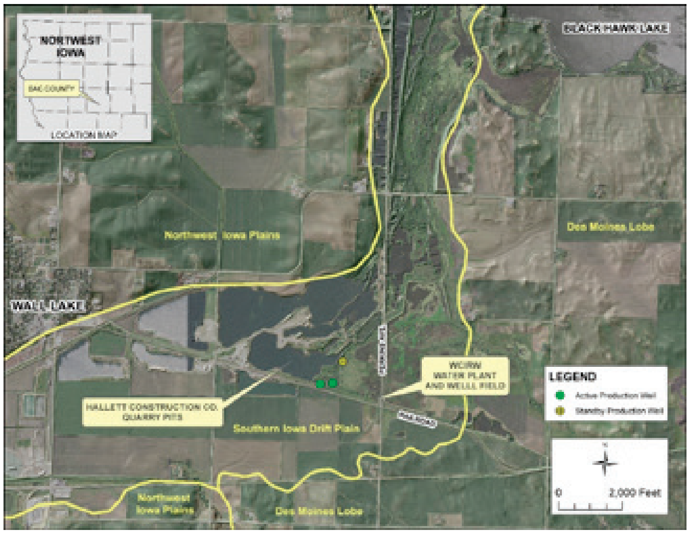

FIGURE 1. LOCATION MAP. The IDNR retained the Iowa Geological Survey to evaluate the impacts the dredge material could have on future water production in the West Central Iowa Rural Water (WCIRW) wellfield, which relies on both groundwater and induced recharge from the adjacent pits for its water supply. The IGS developed and calibrated a groundwater flow model to evaluate whether or not fine-textured dredge material would reduce or seal the hydraulic connection between the former Hallett Quarry and the aquifer.

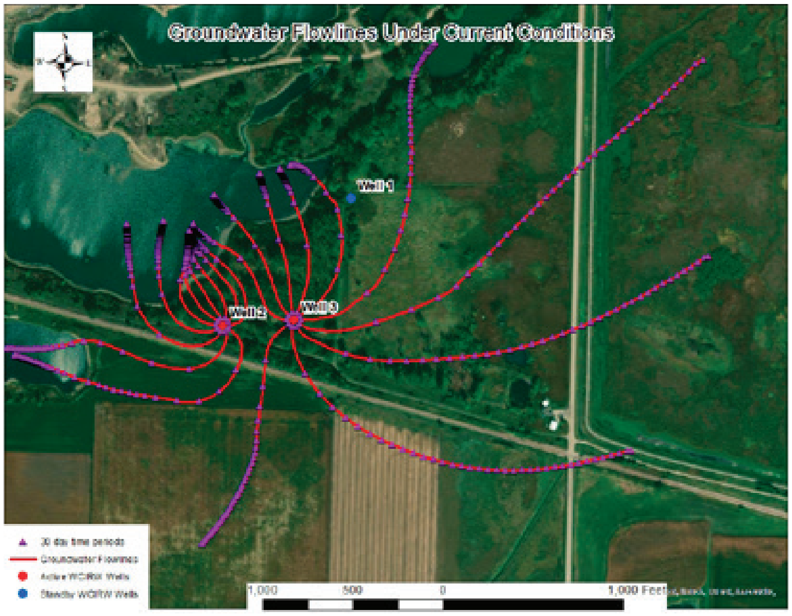

FIGURE 2A. Groundwater flow lines and particle tracking under drought conditions.

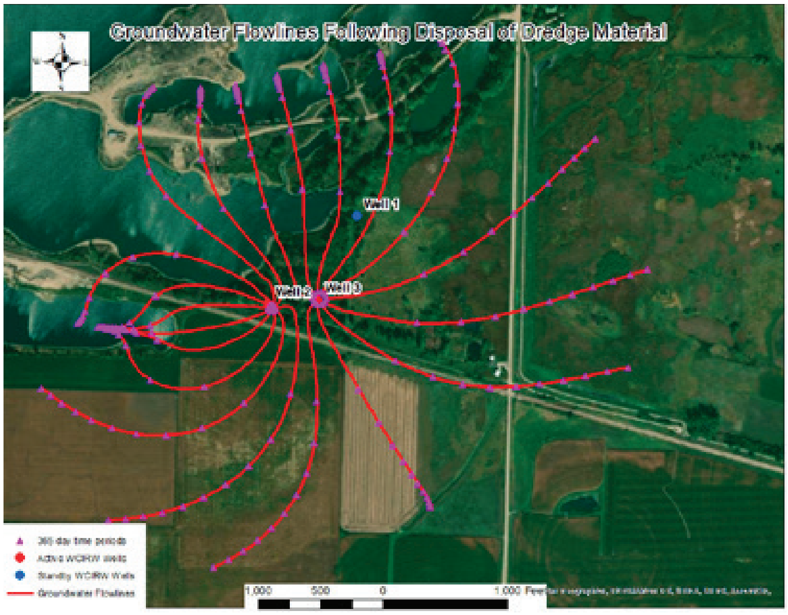

FIGURE 2B. Groundwater flow lines and particle tracking under future drought conditions following disposal of dredge material from Black Hawk Lake.

Assessing the Effectiveness of Alternative Tile Intakes in Southeast Iowa

by Matthew Streeter

SUBSURFACE TILE DRAINS in farm fields ensure timely planting, but they may also "short-circuit" sediment and nutrient pathways from fields to streams. Slotted pipe tile intakes are routinely used to drain surface ponding but they are not very effective at trapping fine sediments, particulate phosphorous, and dissolved nutrients before leaving the fields.

However, a new practice called alternative tile intakes (ATIs) can be installed such that surface water runoff is intercepted before it reaches the main drainage tile. These systems consist of layered pea gravel and wood chip filters that intercept and treat surface water while also working as sediment traps and bioreactors.

In spring 2019, IGS scientists Keith Schilling and Matthew Streeter began a conservation innovation project, funded by the Natural Resources Conservation Service, to quantify reductions in tile nitrate, phosphorus, and sediment concentrations following the installation of ATIs in two fields in Keokuk and Wapello counties. The project has been documenting the effectiveness of ATIs by comparing water samples upgradient and downgradient from the newly installed intakes.

At each site, the IGS installed automatic water samplers and equipment that regularly measure the level of ponding. When a rain event large enough to cause ponding at an ATI site occurred, the automatic water samplers were triggered to collect a sample every 10 minutes for four hours. The collected samples were then analyzed for nutrient and sediment concentrations. The results from the past two years of monitoring are still being analyzed, but the data are encouraging and will be published soon.

"ATIs may offer an advantage over other best management practices, such as bioreactors, because they can reduce sediment and phosphorus losses by 80–98 percent. Moreover, ATIs have the potential to function as bioreactors. The addition of wood chips in ATIs facilitates nitrate breakdown compared to slotted pipe intakes."

KEITH SCHILLING

TOP: ATI site after a large rain event.

ABOVE: Water sampler at ATI site.

Reconstructed Multi-Purpose Oxbows Improve Water Quality and Provide Ecosystem Services

by Sophie Pierce

OXBOWS ARE FLOODPLAIN features that form when river meanders are cut off, leaving them partially or fully disconnected from streamflow. These wetlands provide valuable habitat for aquatic life and waterfowl and can improve water quality by taking up sediment and processing nutrients from runoff. Over time, oxbows often fill in with sediment and organic matter, but they can be restored by dredging out the materials and re-vegetating the oxbow area. Recent Iowa Geological Survey (IGS) research indicates that restored oxbows can reduce nitrate-nitrogen (NO_3-N) from groundwater seepage, overbank flooding, and tile drainage.

The IGS and partners at Iowa State University, the Iowa Soybean Association, and The Nature Conservancy are measuring the effects of reconstructed oxbows on water quality and ecosystem services in agricultural areas of north-central Iowa. The project, funded by the Iowa Nutrient Research Center, aims to characterize the hydrogeology of four recently reconstructed oxbows that capture a range of input water and nutrient sources, evaluate their N and orthophosphate (OP) reduction capacity, and quantify mass load reduction and retention.

Four sites were selected, two oxbows fed by tiles and two non-tiled, in the heavily farmed Des Moines Lobe landform region of north-central Iowa. The IGS conducted geophysical surveys of the oxbow areas using electromagnetic terrain conductivity (EM31) methods to characterize subsurface conditions. Researchers installed water table monitoring wells and piezometers at each site and instrumented them with pressure transducers to measure continuous water levels. The research team is also monitoring discharge from tiles into the oxbow, as well as flow in and out of the oxbow. Water level measurements, flow data, and subsurface geology information will assist in characterizing groundwater flow directions and rates.

Researchers are collecting water samples from groundwater wells, oxbow and tributary surface water, and tile flow input for analysis by the Iowa Soybean Association for NO_3-N, chlorine, sulfate, and OP. Because tile-fed oxbows experience significant fluctuation in NO_3-N levels, a Nitratax probe was installed at the two tiled sites to measure continuous nitrate concentration patterns. The team will use this information to develop a mass balance for the oxbows to quantify water and nutrient budgets. Results from this study will be used to develop design criteria to implement oxbow reconstruction to maximize nutrient reductions and other ecosystem services.

BELOW: Oxbow lake in Kossuth County, Iowa, sampled by the IGS as part of an INRC-funded project focused on the water-quality benefits of reconstructed multi-purpose oxbows.

The Future of Geologic Carb

by Ryan Clark

CARBON CAPTURE, UTILIZATION, and storage represent a rapidly emerging industry in the United States and around the world. Iowa is just beginning its foray into this realm, which is known as CCUS. Although "carbon sequestration" is the popular term for all types of carbon storage, including agricultural conservation practices such as no-till and cover crops, CCUS targets sequestration related to atmospheric carbon emitters.

Carbon capture refers to the process of preventing carbon dioxide (CO_2) gas from being released into the atmosphere. Industrial facilities that exhaust CO_2 can install equipment on smokestacks to grab the CO_2 before it escapes.

Utilization of captured CO_2 aims to find beneficial uses, such as carbonated water for soda (who doesn't like pop?), pharmaceuticals, and industrial applications. This step in the CCUS process does contribute to reducing CO_2 emissions, but it is a relatively small piece of the pie.

Storage is the primary end game for most of the captured CO_2. So where can it be stored? The answer to this question is two-fold and rooted in geology. For over a century, the United States has been producing petroleum as crude oil and natural gas from deposits that developed millions of years ago in bedrock formations buried deep underground. One way to store CO_2 is to inject it down into these petroleum reservoirs. This process, known as enhanced oil recovery (EOR), not only stores the CO_2, but also forces out the remaining petroleum that could not be recovered by conventional methods. The second option involves injecting the CO_2 into deep bedrock formations that can store it indefinitely. This is simply referred to as geologic storage. The ideal bedrock formation for CO_2 storage is one with high porosity (open spaces) and permeability (connectivity between open spaces). Formations such as these are abundant in Iowa and store groundwater that can be pumped out via water wells. Sequestration of CO_2 would operate in much the same way … only in reverse. The captured CO_2 is pressurized to convert it from a gas to a liquid, then injected into the formation where the CO_2 liquid displaces groundwater in the aquifer.

CAN CO_2 BE STORED IN IOWA?

In 2018, the Iowa Geological Survey published a report on the potential for geologic storage of CO_2 in Iowa (Witzke et al., 2018). This study focused on geologic formations in southwestern Iowa for two main reasons: (1) southwestern Iowa is where the vast majority of historic petroleum exploration occurred, including the drilling of numerous deep test holes; and (2) the bedrock formations suitable for CO_2 storage are deep enough (> 2,700 feet below ground) to maintain the pressures necessary to keep the CO_2 in liquid form (Fig. 1). The results of the study identified several possible formations: the Cambrian-Ordovician, Mt. Simon, and "Red Clastics." Target formations were only considered if the quality of the groundwater was too poor to be used as drinking water — otherwise known as deep saline aquifers. Although the study found that Iowa's geology could be suitable for CO_2 storage, more research is needed to appropriately assess these formations before CO_2 storage can begin.

In 2020, the IGS joined a consortium of 19 other states, the Midwest Regional Carbon Initiative (MRCI), to further study whether Iowa can develop CO_2 storage in the future. The MRCI is funded by grants from the U.S. Department of Energy and is led by the Illinois State Geological Survey and the Battelle Memorial Institute, a private, nonprofit applied science and technology company. The goal of the MRCI is to promote CCUS development within its region by addressing key technical challenges, collecting and sharing data, facilitating regional infrastructure planning, and conducting collaborative research.

on Sequestration in Iowa

WHY STORE CO_2 IN IOWA?

Iowa is home to more ethanol plants than any other state in the country. Ethanol production generates nearly pure CO_2, making these plants an ideal source for carbon capture technology. Would it be better to pipeline all that CO_2 to oil fields for EOR or to store it locally in deep bedrock formations? The difference between those options could have huge economic implications for the state. Federal tax credits offer $35 per metric ton of CO_2 captured and used for EOR, while geologic storage earns $50 per metric ton. For an average Iowa ethanol plant producing 100 million gallons of ethanol per year, that difference equates to around $4.5 million, or $189 million statewide annually — a new income stream. Furthermore, if Iowa adopts geologic storage, it would allow ethanol producers to sell their product at a premium to states that have adopted low carbon fuel standards, which could provide financial sustainability after the tax credits expire.

Iowa is currently behind neighboring states in the CCUS industry. Kansas and Illinois began CO_2 storage in 2009 and 2011, respectively. North Dakota has multiple projects in the works, including an ethanol plant and a power generation facility that may begin CO_2 injection within the next few years.

Although it may take several years to fully assess whether Iowa's geology can support a CO_2 storage program large enough to alleviate the output of so many ethanol plants, this timeline should not deter our efforts. Rarely does an opportunity come along that offers such economic impacts coupled with even greater environmental benefits. Investing in the research and development now could place Iowa among the global leaders in the vital CCUS industry.

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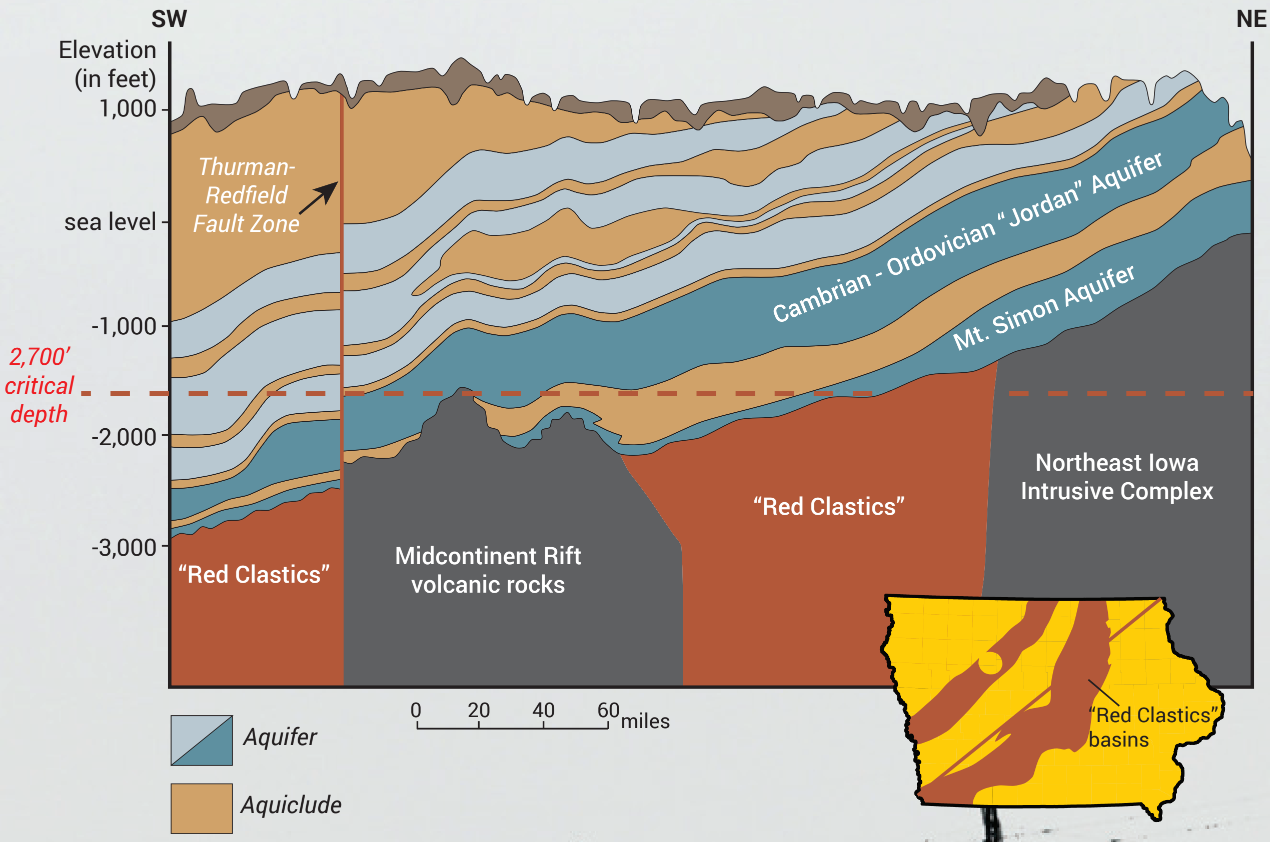


FIGURE 1. Generalized geologic cross-section of Iowa from northeast to southwest. Paleozoic bedrock aquifers are shown in shades of blue. Precambrian bedrock is divided into crystalline bedrock (igneous and metamorphic) in green and deep sedimentary basins of the Midcontinent Rift System in orange. Modified from "Iowa's Groundwater Basics," Prior et al., 2003.

IGS Groundwater Network Monitors Iowa's Aquifers

by Rick Langel

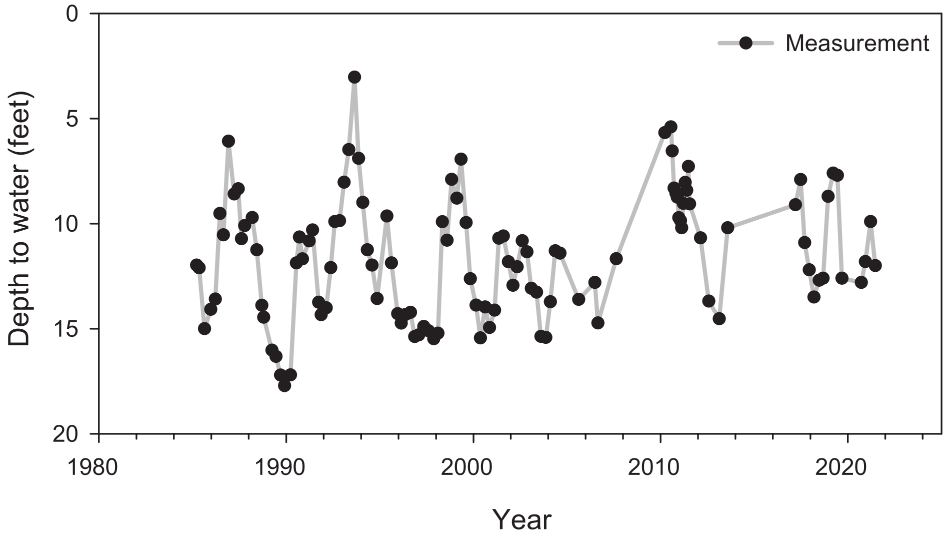
GROUNDWATER IS AN important natural resource in Iowa. While hidden below the surface, roughly 65 percent of Iowans depend on groundwater for their water supply. The IGS maintains a groundwater level network to provide a consistent, high-quality record of water levels in Iowa's aquifers. The network currently consists of 57 dedicated monitoring wells in four major bedrock aquifers that are measured at least quarterly. The network was formally established in 1982, thus many wells have long-term records.

One goal of the network is to provide data for accurate calibration of groundwater models. The network's data are ideal for groundwater models because the information is collected by consistent methods over time. Groundwater models of the Cretaceous and Silurian aquifers use water level data collected from this network. The IGS uses these models to help communities and industries plan for future water supply needs, evaluate well interference complaints, and to help regulators prevent over-allocation of water resources.

Another goal of the network is to provide a record of water level changes in the state's aquifers. Groundwater levels fluctuate with the seasons and precipitation. Because many wells in the network have long-term records, researchers and regulators can compare current levels to historic data that were collected during droughts or periods of increased precipitation. Groundwater levels in many of the network's wells display seasonal fluctuations, but long-term trends are not evident (Fig. 1). However, the water levels in a majority of the Cretaceous Dakota aquifer wells in northwestern Iowa show long-term declines (Fig. 2). This indicates that more water is withdrawn from the Dakota aquifer than is being replenished to the aquifer, meaning the Dakota aquifer is being depleted.

Collaboration with the National Groundwater Monitoring Network (NGWMN) enhances the IGS network. The IGS submits its network data to the NGWMN, allowing researchers to evaluate and model aquifers at regional and national scales. In turn, grants from the NGWMN support efforts by the IGS to evaluate and maintain individual wells in the network. The grants have paid for IGS projects to pump water from, and conduct scientific tests in, wells to ensure that they are still functional. If needed, the IGS can request funds for well rehabilitation or replacement.

FIGURE 1.
Water level data from a Silurian aquifer well showing seasonal fluctuations with no obvious trend.



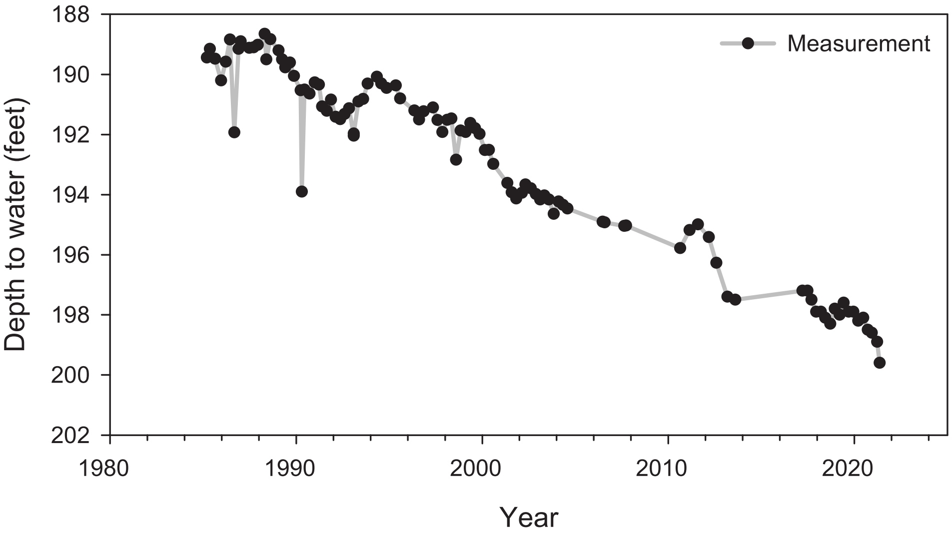


FIGURE 2.
Data from a Cretaceous Dakota aquifer well illustrating a steady decline in water levels over time.

Groundwater Recharge in Iowa

by Keith Schilling, State Geologist

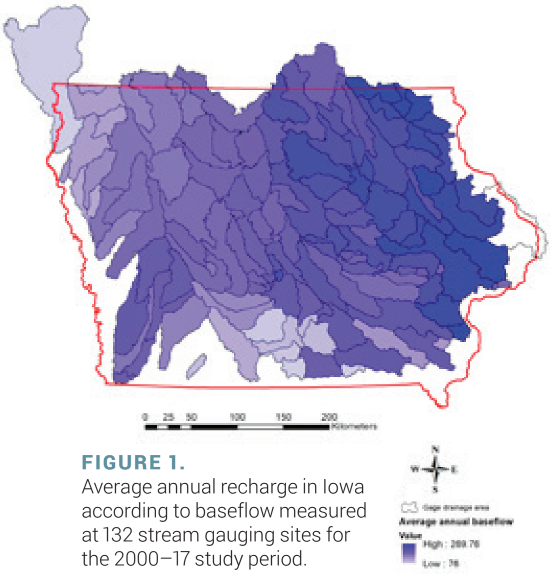


FIGURE 1.
Average annual recharge in Iowa according to baseflow measured at 132 stream gauging sites for the 2000–17 study period.

DURING DROUGHT PERIODS such as the one we just experienced in 2021, everyone is well aware that the grass is brown and the soils are dry and cracking. Folks also know that what we are missing is rainfall. What is less obvious is the need for rainfall to recharge our shallow groundwater supplies; groundwater can be just as vulnerable to drought as your lawn.

When precipitation falls on the land surface, some of it runs off to nearby streams, but some of it soaks into the ground, percolates down through the soil profile, and enters the water table in a process known as "groundwater recharge." Once water enters the groundwater system, it slowly travels to low areas where it seeps into streams, wetlands, and lakes. Vegetation pull up some shallow groundwater through root systems, which is then discharged back to the atmosphere by plant transpiration. Some groundwater may seep deeper into lower strata and recharge deeper aquifers. However in many areas, such as along major river corridors, shallow groundwater is pumped out of the ground via wells for water supplies and irrigation. Many public water supply systems in western and central Iowa use these shallow alluvial groundwater sources for their water supply.

As such an important component of the hydrologic cycle, groundwater recharge is notoriously difficult to measure and quantify at regional scales, such as across the state of Iowa. Over large spatial scales, scientists have often relied on regional numerical models for recharge estimation; they make assumptions during model calibration.

However, new research from the Iowa Geological Survey (IGS) used measurements of baseflow discharge to streams to quantify groundwater recharge patterns across the state. The IGS estimated the recharge by assuming that the amount of groundwater discharging to rivers as baseflow is approximately equal to the amount of recharge entering the water table. We quantified this baseflow "recharge" at 132 U.S. Geological Survey (USGS) stream gauging locations across Iowa.

When the distribution of the baseflow across the state was interpolated, annual groundwater recharge in Iowa averaged approximately 8.7 inches in any given year and increased from west to east across the state (Fig. 1). By comparing this annual recharge value to average annual rainfall, it appeared that about 25 percent of rainfall enters the water table as groundwater recharge each year. However, annual recharge can be extremely variable, ranging from 2.8 to 18.4 inches across a 18-year period from 2000 to 2017. Recharge was found to be particularly concentrated in the months of May and June, which account for about two-thirds of the annual amount (Fig. 2).

During a severe drought year (like 2012), the state receives only about 2–3 inches of groundwater recharge. When this occurs, there are consequences for water supply providers, river enthusiasts, and, of course, agriculture. Drought losses are the largest category of U.S. Department of Agriculture (USDA) crop insurance payments made to Iowa agricultural producers. The data show that drought payments substantially increased when annual groundwater recharge was less than approximately 5 inches per year.

Overall, groundwater recharge is an important component of the water budget for the state, and new research results provided by the IGS can help Iowans better understand their water resources.

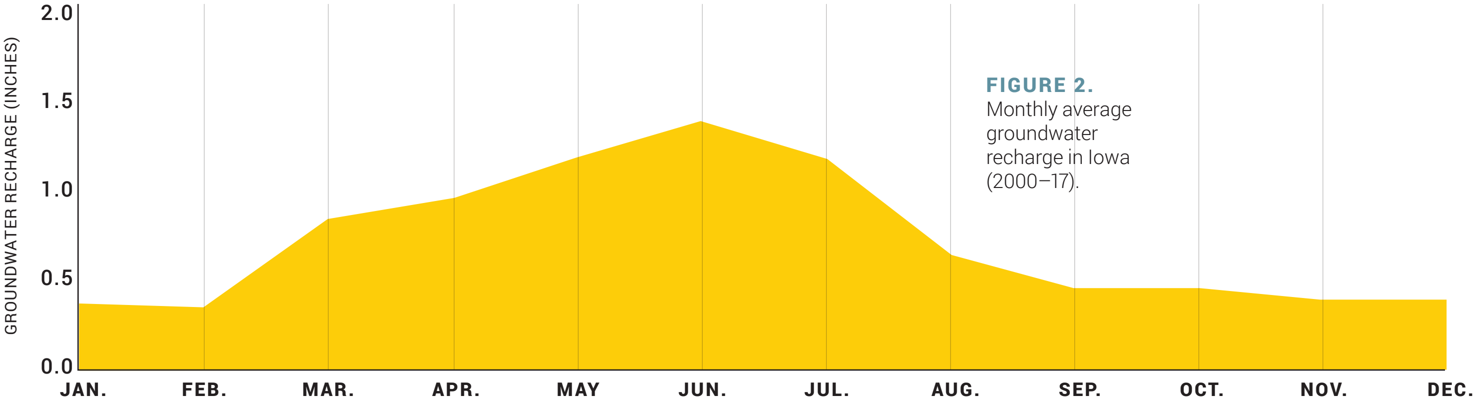


FIGURE 2.
Monthly average groundwater recharge in Iowa (2000–17).

Bedrock Topography Mapping Using the Passive Seismic Method

by Greg Brennan

THE IGS HAS a new tool to study the bedrock surface in a cost-efficient manner: the passive seismic method.

The passive seismic method is a non-invasive survey technique dependent on earth vibrations that continually propagate throughout the subsurface. When such vibrations are filtered to remove spurious noise (e.g., wind, vehicle traffic, etc.), the method can be used to determine the depth to the bedrock surface.

The bedrock surface is the interface between the unconsolidated surficial deposits and the consolidated rocks that compose bedrock. The altitude and configuration of this buried surface can be known and represented on a map by contour lines or as a computer-generated raster surface. An accurate bedrock topography map is of great value for studying a wide variety of geologic, hydrologic, and environmental issues; the mapping of aquifers for potable water supply is just one example.

The primary control for such a map is found in geological logs from quarries and outcrops. The accuracy of the map is related to the density of control points; the greater the number of control points in a given area, the more reliable the mapping of the bedrock surface will be. However, control point data can be sparse in some areas, which can cause the map to have a high level of uncertainty. Increasing the control point density is thus advantageous but it can be costly if drilling is the sole method of investigation. The passive seismic method is a cost-efficient geophysical alternative to drilling.

The peak frequency measured by the passive seismic unit is controlled by the layer(s) that overlie bedrock, reflecting the contrast in the density and seismic velocity of the materials juxtaposed at a geologic contact.

The passive-wave seismograph instrument used by the Iowa Geological Survey is called Tromino® designed by MOHO Science & Technology. This portable instrument has proven reliable, durable, and cost-efficient. Each measurement takes about a half hour to collect.

The IGS recently used the passive seismic unit to assist in mapping Benton County for the STATEMAP program. Although 1,825 well logs, of which 1,171 intersected the bedrock surface, were already available across the county, significant gaps in coverage still existed. In 2020, IGS staff used the unit to collect data at 66 sites throughout the county where drilling logs were sparse to non-existent or had uncertain interpretations. The resulting bedrock elevation map was dramatically improved, offering a better understanding of the bedrock topography and its relationship to geologic mapping units. In particular, several deep bedrock valleys were delineated that cross the south-southwest portion of the county (Fig. 1).

Overall, the passive seismic system allows IGS geologists to better delineate subsurface patterns and improves our ability to evaluate groundwater vulnerability and aquifer extent.

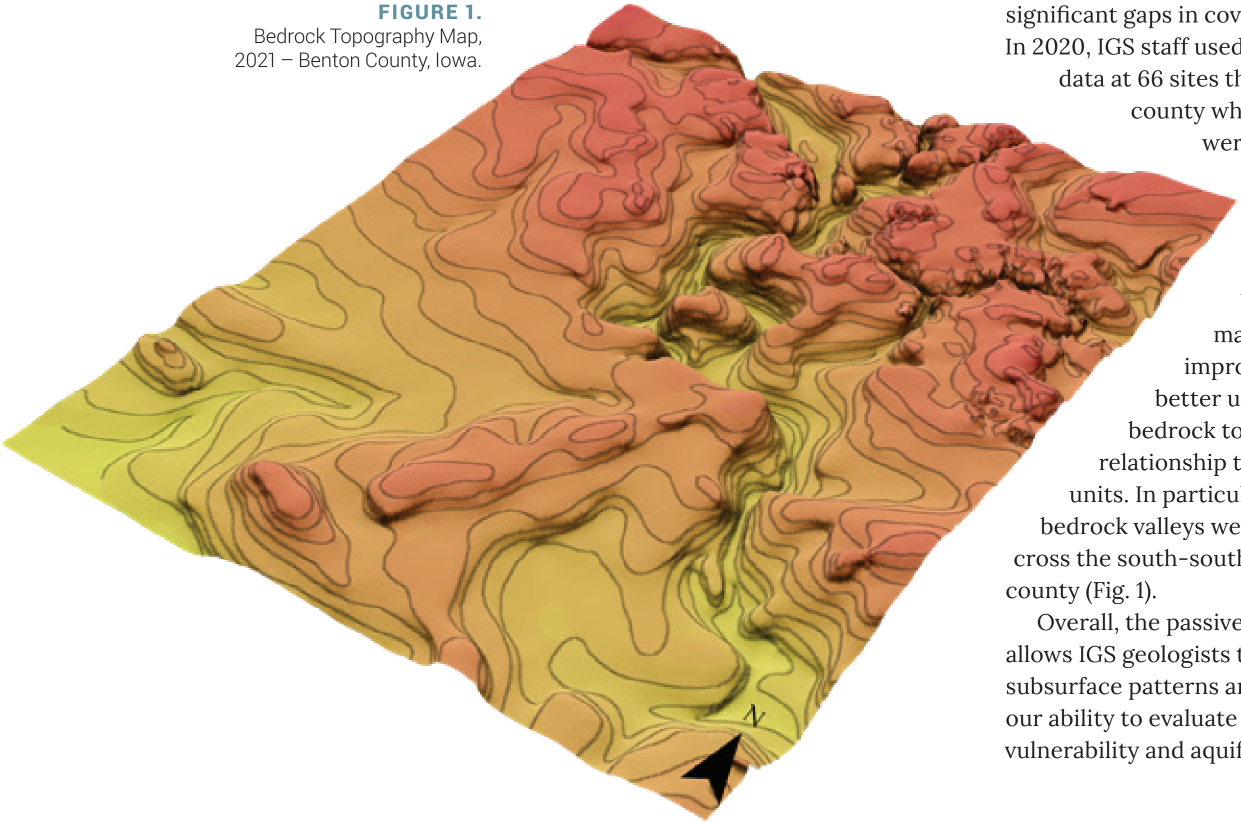


FIGURE 1. Bedrock Topography Map, 2021 – Benton County, Iowa.

New Insights into the Landscape Development of Benton County

by Phil Kerr

IOWA'S LANDSCAPE HAS been reshaped throughout geologic history. The most recent modifications to the land surface occurred during the Quaternary Period (2.6 million years ago–present) as a result of the advancement of continental ice sheets.

Recent geologic mapping in Benton County illuminates the geomorphic processes that occurred in this area of east-central Iowa, including parts of the Cedar and Iowa river valleys (Fig. 1). Glacial sediments from the Pre-Illinoian Episode (~500,000 years ago) dominate the surficial geology of the area. Since the ice retreated, the landscape has undergone fluvial incision, and the glacial deposits have experienced weathering and soil development. During the Late Wisconsin Episode (~27,000 – 12,000 years ago), rivers received massive amounts of glaciofluvial sediment from glaciers. Windblown silt, called loess, from these valleys was deposited on the landscape. These deposits could be eroded where sand could blow across the landscape.

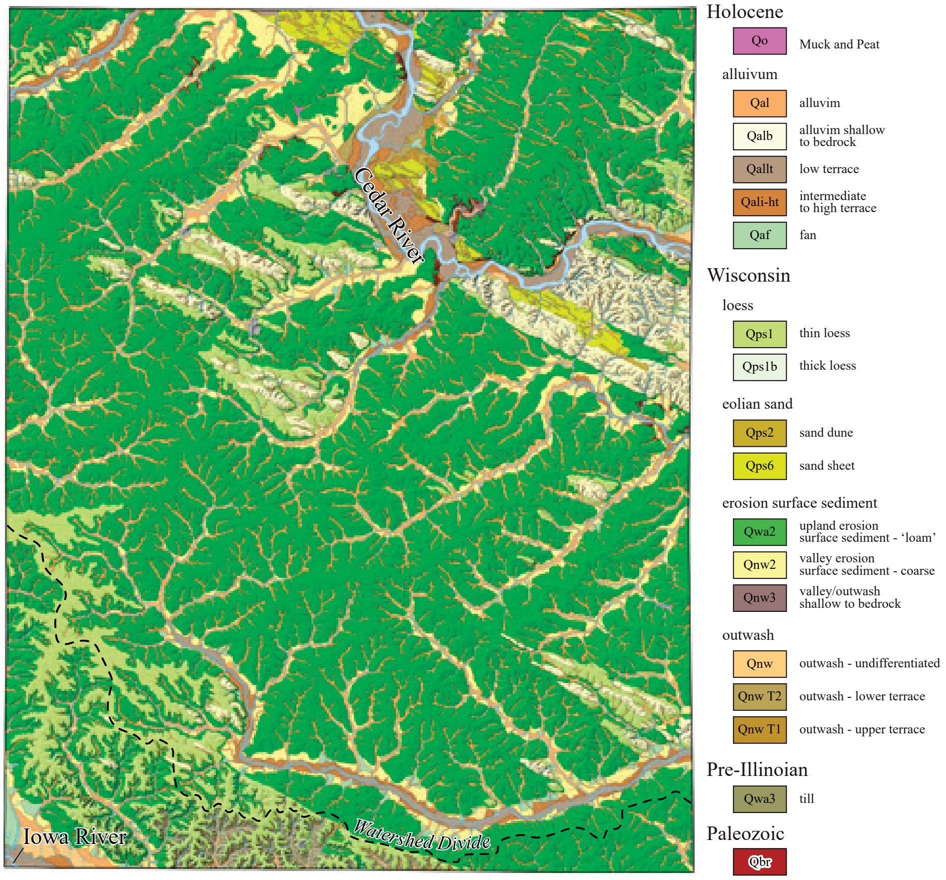
Benton County lies within two landform regions; the Iowa River Watershed is in the southwestern corner of the county and is largely within the Southern Iowa Drift Plain (SIDP) landform region. The landscape consists of rolling hills and sizable valleys and is largely dissected by streams. Tributaries of the Iowa River in southern Benton County are deeply cut into the landscape. The upland has thick (>5m) Late Wisconsin loess deposits.

The northern part of the county is in the Cedar River watershed. This area is part of the Iowan Surface landform region, commonly referred to as the Iowan Erosion Surface (IES). The topography of this region is subdued but has an integrated drainage network with broad, underfit valleys. Unlike the SIDP, upland stratigraphy consists of thin (< 1m) loess over weathered Pre-Illinoian till — with no intervening paleosols. The IES experienced a period of landscape-wide periglacial erosion during the Late Wisconsinan Episode, which flatted the topography by filling valleys with eroded material from the upland. This region also contains distinctive aligned hills, called paha, which rise above the surrounding landscape. These ridges are characterized by their thick loess deposits and, curiously, often include the missing paleosols not found on the surrounding upland. A recent mapping project has illuminated the relationship between the SIDP and IES.

The key factor is the west-northwest orientation of the landscape — the prevailing wind direction during the Late Wisconsin. Outwash carried by the Iowa and Cedar rivers was likely a source for the loess and eolian sand in the area. The shape of the valley plays a large role in eolian features. The Cedar River has many turns throughout its course, and its valley geometry is controlled by the underlying material. Areas where bedrock outcrops create steep walls, but sections in thick glacial sediment have broad floodplains. In Benton County, windblown sand could exit the floodplain in the portions of the Cedar River with gently sloped valley walls of glacial sediment. These stretches have extensive sand sheets and parabolic dunes downwind. Conversely, the bedrock-lined areas have thick loess deposits rather than eolian sand downwind. Parabolic dunes, paha orientation, and sand stringers all have the same orientation, WNW, which was the effective wind direction. The connection between topography and wind direction is demonstrated by thick loess found downwind of bedrock-lined portions of the Cedar River.

Unlike the Cedar River, the Iowa River was generally more in line with the WNW wind for most of its river course, which kept most of the sand in the valley. Sand starts leaving the valley when it starts to turn to a more east-west course in Iowa County. The unique features and deposits in Benton County show that eolian processes during the Wisconsin Episode were a dominant force, reinforcing the idea of a transport surface model for the development of the Iowan Erosion Surface.

FIGURE 1.
The surficial geologic map of Benton County, Iowa. The Cedar and Iowa watershed divide is shown with a hashed line.



SINKHOLE AND KARST SUSCEPTIBILITY MAPPING IN NORTH-CENTRAL IOWA:

Using Geologic Maps to Inform

by Stephanie Tassier-Surine, Phil Kerr, Ryan Clark, and Jason Vogelgesang

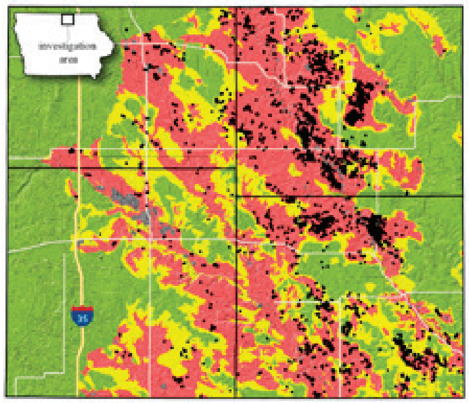


FIGURE 1.
Updated karst susceptibility map for north-central Iowa. Red, yellow, and green colors on the map correspond with areas that have high, medium, and low susceptibility to form karst, respectively. Black dots represent the sinkholes that were identified during this study.

IOWA'S VARIED GEOLOGIC history has resulted in a range of potential hazards to public safety and infrastructure. One such hazard is the natural dissolution of near-surface carbonate bedrock (limestone and dolostone) that can lead to surface subsidence and the formation of sinkholes, caves, and disappearing streams, collectively known as karst.

Sinkholes are especially problematic in karst terrain, as they can result in costly damage to roadways, retaining walls, and other structures.

The Iowa Geological Survey (IGS) recently completed an extensive update to the sinkhole and karst susceptibility map for Worth, Cerro Gordo, Mitchell, and Floyd counties in north-central Iowa. Funding from the Iowa Department of Transportation (IDOT, project number HR-3018) made this project possible. The primary goals of the project included using updated maps and modern technology to identify sinkholes and depressions, as well as to update the karst susceptibility map of the four-county study area (Fig. 1).

The original sinkhole data for Iowa were based on the Natural Resources Conservation Service (NRCS) county soil surveys, which vastly underrepresent the number of sinkholes in the state. Hallberg and Hoyer (1982) later completed the IGS's first comprehensive sinkhole mapping project. The availability of LiDAR (light detection and ranging) in 2010 led the Iowa Department of Natural Resources (IDNR) to update an eight-county area in northeast Iowa; this contributed significantly to the NE Iowa Watershed and Karst Map (Hruby et al., 2010). However, the sinkhole map for the current project area was not updated during this effort.

The IGS used a variety of data sources (LiDAR digital elevation models, LiDAR hillshade, LiDAR cut and fill tool, historic aerial photos, NRCS spot symbols, topography, and vegetation maps) in the initial phase of the study. Researchers identified a total of 5,401 depressions, a vast increase from the 2,425 sinkholes mapped in the existing data set.

A more in-depth evaluation was then conducted for each depression, including comparison with updated

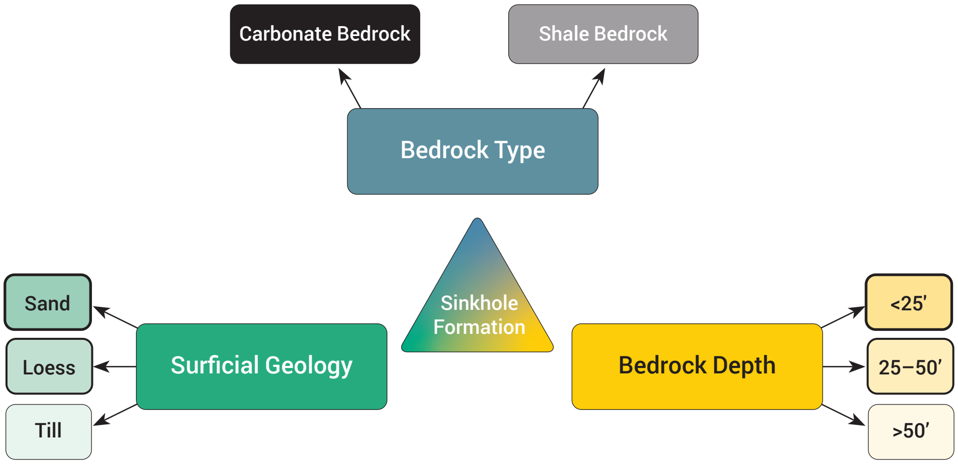


FIGURE 2: FACTORS FOR SINKHOLE DEVELOPMENT MATRIX.
Karst susceptibility matrix. High, medium, and low classifications are determined by dominant bedrock type (carbonate or shale), upland or valley position, and depth to bedrock.

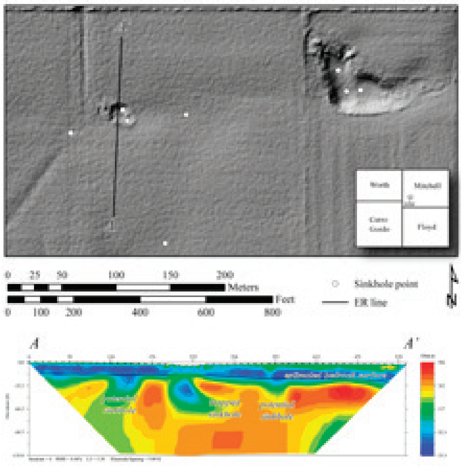


FIGURE 3.
Geophysical results for the Rachut site including the LiDAR hillshade image (top), with mapped depressions as white circles and the cross-sectional ER profile (bottom). Note the presence of the low resistivity area (cool colors) below the location of the mapped sinkhole, as well as two additional low resistivity areas that are not apparent at the surface.

geologic maps. County-scale surficial and bedrock geologic maps produced by the IGS between 2012 and 2018 provided an improved understanding of the lithologic character and distribution of the geologic units. These recent bedrock geologic maps subdivided the bedrock units at the formation level, rather than at the group level as provided by the Bedrock Geologic Map of Iowa (Witzke et al., 2010). The Lime Creek Formation was also remapped at the member level as part of the current project.

The IGS also evaluated surficial geologic maps that were not available for this area in previous karst studies; this allowed researchers to determine the level of influence surficial materials may have on sinkhole formation. Surficial geology did not appear to have a significant impact in upland areas, likely because of glacial till acting as an aquiclude (a geologic unit that inhibits the flow of water). However, the surficial geology is thought to aid in sinkhole formation in the valleys, where sand and gravel are present and do not restrict water infiltration to the bedrock surface. Here, the sand and gravel may also mask the surface expression of sinkholes, making them harder to identify.

Records from new wells drilled since the geologic maps were produced were also incorporated, and passive seismic geophysical field data were collected to confirm the bedrock depth for areas with limited information.

After all data were assessed, a total of 4,175 of the depressions initially identified were interpreted as sinkholes. Anthropogenic features and depressions related to surficial geology (e.g., sand dunes) were the most common reasons that points were not considered sinkholes.

The IGS assessed karst susceptibility by categorizing each location based on bedrock type, surficial geology, and the depth to bedrock. This assessment established a matrix assigning each combination as having a high, medium, or low potential to form karst (Fig. 2). Bedrock was considered to have a high karst potential if it was composed predominantly of carbonate and was less than 25 feet below the land surface; medium or low potential was assigned when shale was the initial bedrock lithology and/or if bedrock was greater than 25 feet deep. Surficial units were grouped into upland and valley settings. Upland settings are more likely to be mantled with relatively impermeable till deposits and therefore are less likely to form karst. Data from valley settings indicate that sand and gravel is present at the surface; however, there was not always sufficient information to determine if a less permeable till unit was present between the sand and gravel and the bedrock surface. Therefore, all valley units that were less than 50 feet to bedrock were considered to have a high karst potential. Statistical validation of the karst potential groupings showed that 85 percent of the sinkholes occurred in areas where the bedrock surface was within 25 feet of the land surface. The most common bedrock units hosting sinkholes were the Devonian Lithograph City Formation and Cretaceous outliers.

The field assessment included electrical resistivity geophysical surveying (ER) at three locations in the study area to investigate the subsurface character of sinkholes and sinkhole complexes. Each location was in an area where bedrock was less than 25 feet from the surface. Two were in upland settings with glacial till overlying carbonate bedrock. Of the two sites in upland settings, one was actively being farmed (Rachut site) and the other was grassland that had not been farmed in many years (Mitchell County Conservation Board site). The third site (Falk site) had sand and gravel overlying shallow carbonate bedrock and was actively farmed. In all cases, a low resistivity zone was identified in the vicinity of a mapped sinkhole. At the Mitchell County Conservation Board site, an area of low resistivity was identified between sinkholes and beneath what appeared to be competent bedrock. This interesting discovery suggests that sinkholes may be connected at depth, even if surface expression is not apparent. Results from the Rachut site in Fig. 3 show the ability to image both known and unknown subsurface features.

The IGS more than doubled the number of mapped sinkholes in Worth, Cerro Gordo, Mitchell, and Floyd counties and made substantial improvements to the karst susceptibility map for the study area. The study identified two primary factors that affect the formation of sinkholes: the depth to the bedrock surface and bedrock lithology (carbonate versus shale). The bedrock geologic map units dominated by carbonate lithologies correlated very closely with the areas that formed sinkholes, and most sinkholes occur in areas where the bedrock surface is less than 25 feet below the land surface. This study illustrates the need for more detailed bedrock elevation and geologic maps in karst-prone areas of Iowa. An assessment of the surficial geologic mapping units helped determine if depressions were sinkholes, demonstrating that the surficial geology is an effective screening tool for sinkhole evaluation.

Karst has long been known to have a significant impact on infrastructure in areas of Iowa with certain geologic conditions. A better understanding of the sinkhole distribution and likelihood could increase safety and avoid costly repairs.

For bedrock and surficial geologic maps, see the IGS publications website: **https://tinyurl.com/djnuf8.wm**.

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The IGS Rock Library

by Rick Langel

PHOTOS THIS PAGE: Ryan Clark in the IGS Rock Library.

FROM THE OUTSIDE, the Iowa Geological Survey Oakdale Repository looks like just another unimposing warehouse. Inside, however, treasure awaits.

The repository, located at the University of Iowa's Oakdale Research Park campus, stores immensely valuable collections of geological information. The facility is home to well records, soil samples, and rock samples collected from all regions of Iowa. Like a library, the materials are collected, catalogued into databases, and curated for long-term preservation. When information is needed, the material can be retrieved and studied, just like in a library.

The samples are preserved in cardboard boxes stacked on wooden or metal shelves. The location of each box and its contents are catalogued in online databases. When samples need to be analyzed, they are moved from the shelves to better-lit workspaces that feature equipment such as microscopes and cameras.

The water well records collection is the most frequently accessed. Well records commonly include information on the type and thickness of the geologic materials encountered, the kinds and amounts of materials used in a well, and the construction techniques used to build it. The IGS's collection has information on over 86,000 wells in the state, with paper records for more than 76,000 of those wells.

The collection of well chip samples and rock cores is commonly referred to as the Rock Library. Well chips are fragments of soil and rock that are flushed to the surface while drilling a well. Well contractors commonly use strainers to collect these chips in five-foot intervals. Rock cores are solid, continuous cylindrical sections of rock collected when precise, detailed geologic information is required at a location. The Rock Library contains well chip samples from over 37,000 Iowa wells (representing ~1,700 miles of drilling) and rock cores from roughly 1,300 Iowa boreholes (representing ~28.5 miles of drilling).

A variety of users access these collections. Well contractors, consultants, and engineers use the water well records to estimate the depth to major geologic features, the well depth and likely construction methods needed for a new well, and the water level and yield of certain aquifers.

IGS geologists primarily use the well chips to improve our understanding of the geology in the state. With this expanded knowledge, IGS staff create new maps utilized by local, state, and national entities to identify aggregate and mineral resources, understand the characteristics of aquifers, and study groundwater vulnerability. The recent discovery of the Winneshiek Lagerstätte, an important paleontological discovery with rare fossil preservation, can be partially attributed to the examination of well chips.

Rock cores provide academic scholars and exploration companies with detailed geologic information. Scholars use rock core samples to date and analyze rocks for elements associated with critical mineral deposits. Exploration companies test rock core samples for suitability of aggregate and mineral production.

The collections at the IGS Rock Library are open to the public by appointment. Many of the collections are also available on the IGS website at **https://iowageologicalsurvey.org/data-and-publications/**.

Investigations with the Office of the State Archaeologist

by Matthew Streeter

THE IGS COLLABORATED with the Office of the State Archaeologist (OSA) at the University of Iowa on multiple drilling excursions. These investigations were designed to determine the need for more intense archaeological investigations to locate, record, and preserve prehistoric artifacts from locations slated for development or in locations deemed at risk of natural destruction.

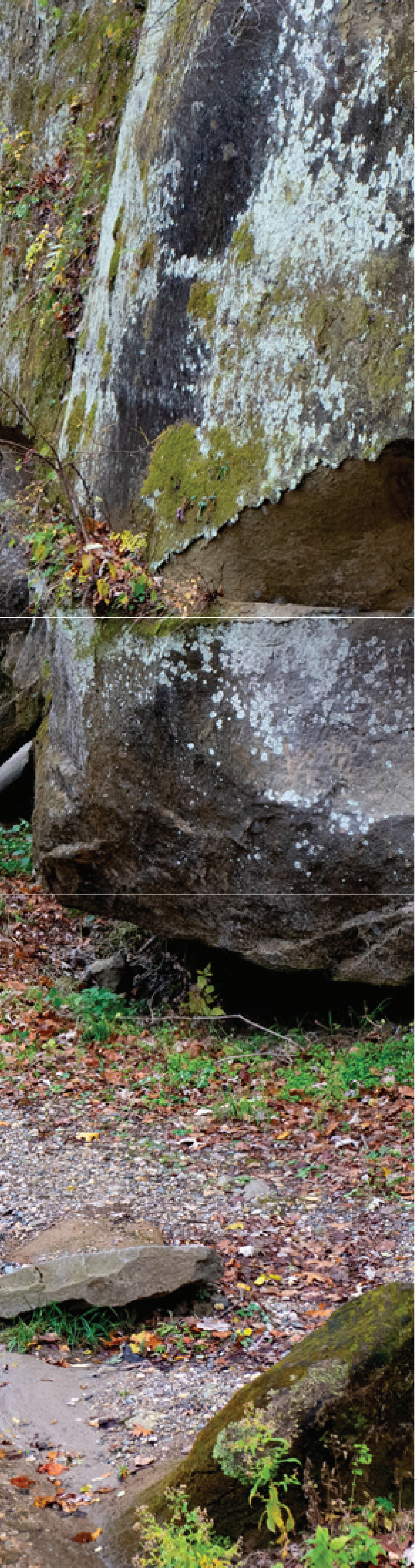
In 2020, IGS Soil Scientist Matthew Streeter worked with OSA Archaeologist Bryan Kendall to identify potential settlement locations of the Mill Creek culture (approximately AD 1000) along sections of the Big Sioux River in Plymouth County, Iowa (Fig. 1). They also collaborated on two projects in the city of Des Moines, Iowa, to locate potential settlements near the Des Moines River (Figs. 2 and 3). These preliminary studies provide archaeologists with important soil and geological information to guide future work. In low-lying areas (such as floodplains), this primarily involves differentiating between buried river channels (not a good place for a settlement) and buried floodplain soils (a likely place for a settlement).

R.H. Sin once wrote, “Bury the past, keep the lessons.” Indeed, humans do a tremendous job of literally burying their past, but records of the lessons from prehistoric times are scarce. Recording and preserving the past and the lessons learned is the purpose of these types of investigations. This is especially important in locations such as Des Moines where prehistoric communities dwelt along the Des Moines River and its tributaries. Now, however, after centuries of development, most remnants are buried deep below our feet.

FIGURE 1.
A soil core is described in Plymouth County to identify potential settlement locations of the Mill Creek culture.

FIGURES 2 AND 3.
Soil cores are collected beneath a major street in Des Moines to identify native settlement locations prior to European settlement.

Escape to Ledges State Park



by Alyssa M. Bancroft

LOOKING TO RECONNECT with nature during these unprecedented times? Consider a visit to Ledges, one of Iowa's oldest state parks. Dedicated in 1924, Ledges State Park encompasses 1,117 acres of land in south-central Boone County, approximately 15 miles west of Ames.

The name itself, Ledges, is an indication that the terrain of the park is quite unusual, given its location within the Des Moines Lobe landform region of central Iowa. The bluffs exposed along Pea's Creek are made of sandstone of the Cherokee Group, which also consists of shales, limestones, and coals deposited about 310 million years ago during the Pennsylvanian Period.

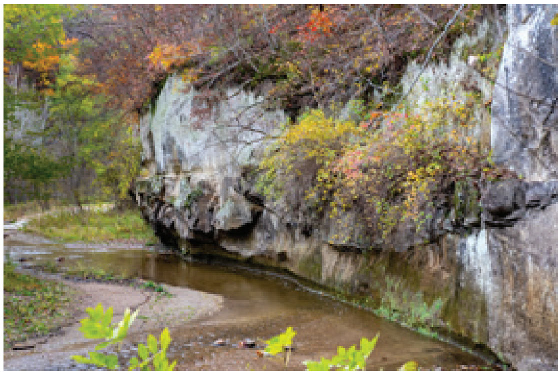
These sandstones were initially deposited as sand in a river delta environment during a time when the sea level changed rapidly. Once buried, these sands were cemented (lithified) with calcium carbonate precipitated by groundwater. The lower portions of these channel sandstones have a reddish color because the calcium carbonate cement was replaced with iron oxides (also by groundwater). The cement dictates how the sandstone weathers (or erodes). The sandstones in the upper part of the bluffs have a higher amount of calcium carbonate and are more resistant to weathering, creating the "ledges" that occur throughout the park.

Ledges State Park appears in its present-day form due to the advance and retreat of continental ice sheets during the Quaternary Period (2.6 million years ago – present). The Des Moines River and its tributaries were established 14,000 to 11,000 years ago during the wastage of the Des Moines Lobe glacier. Meltwater carved through the glacial deposits and underlying Pennsylvanian bedrock, shaping the picturesque bluffs along Pea's Creek. This downcutting has left erosional features, such as scalloped ledges and smoothly rounded faces that showcase the power of water flowing at a rate and volume much greater than the creeks we see in the park today.

The Civilian Conservation Corps constructed many of the structures (trails, bridges, shelters) at Ledges State Park during the 1930s using native timber and fieldstones (glacial erratics).

This park offers the chance to engage in a variety of outdoor activities: Canyon Drive provides motorists with spectacular views of the Des Moines River valley and Pea's Creek canyon; there are five picnic areas and two shelters; over four miles of trails offer spectacular views (Crow's Nest, Inspiration Point, Table Rock); and easier treks lead to Lost Lake or through restored prairie. There are a variety of camping options, as well as an access point to the Des Moines River for those interested in fishing, canoeing, or kayaking. During the winter months some of the trails and Canyon Drive (although closed to vehicles) can still be accessed for hiking, snowshoeing, or cross-country skiing.

Ultimately, Ledges State Park is a fantastic place to escape the daily grind and experience some of the natural wonders of Iowa.



ALL PHOTOS THIS SPREAD: Fall colors at Ledges State Park. Photos by Aneta Goska

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Tassier-Surine, S.A., **P. Kerr**, and S.M. Kilgore, "Middle Wisconsin MIS3 Glacial Advance in Iowa: Defining the Sheldon Creek Formation," North Central Section Geological Society of America, April 19, 2021

Vogelgesang, J.A. and **S.M. Pierce**, "Virtual ER Training Session 1: Introduction to Methods and Concepts," Iowa Department of Transportation (IDOT), June 22, 2021

Vogelgesang, J.A. and **S.M. Pierce**, "Virtual ER Training Session 2: Array Set-Up and Field Preparation," IDOT, June 24, 2021

Vogelgesang, J.A. and **S.M. Pierce**, "Virtual ER Training Session 3: Creating Terrain Files Using ArcGIS," IDOT, June 25, 2021

Vogelgesang, J.A. and **S.M. Pierce**, "Virtual ER Training Session 4: Data Processing with AGI EarthImager 2D," IDOT, June 29, 2021

Vogelgesang, J.A. and **S.M. Pierce**, "Virtual ER Training Session 5: Processing Noisy Data and ER Case Studies," IDOT, July 1, 2021

Vogelgesang, J.A., "Electrical Geophysical Data Collection: A Field Overview of ER and EM Methods," University of Iowa Earth and Environmental Sciences field demonstration, March 26, 2021

Vogelgesang, J.A., "Using High-Resolution ER to Estimate Hydraulic Conductivity and Improve Characterization of Alluvial Aquifers," University of Iowa IIHR—Hydroscience and Engineering, Water Quality Group, July 9, 2021

IGS Projects 2020–21

A Vision Toward a More Resilient Iowa Great Lakes: Keith Schilling: Iowa Department of Natural Resources (IDNR)

Advanced Modeling of Soil Erosion, Sediment Delivery and Nutrient Export from Iowa Watersheds: Matthew Streeter: Iowa Nutrient Research Center (INRC)

Archaeological Investigation near Coralville Reservoir: Matthew Streeter: Rolling Hills Consulting Services

Assessing the Effectiveness of ATIs in Three Representative Regions of Iowa: Keith Schilling: U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS)

Assessment of the Relation between Turbidity and Total Phosphorus: Keith Schilling: IDNR

Black Hawk Lake Data Analysis, Modeling and Reporting: Mike Gannon: IDNR

Connecting Rural and Peri-Urban Farmers to Demonstrate and Disseminate Innovative Nutrient and Sediment Reduction Practices: Craig Just: U.S. Environmental Protection Agency

Developing Areas and Impaired Watershed Mapping in Southeast Iowa: Bedrock and Surficial Geologic Maps of the Donnellson and West Point Quadrangles: Stephanie Tassier-Surine: U.S. Geological Survey (USGS)

Developing Areas and Impaired Watershed Mapping in Southeast Iowa: Bedrock and Surficial Geologic Maps of the New London, Pleasant Grove, Argyle, Nauvoo, and Keokuk Quadrangles: Stephanie Tassier-Surine: USGS

Earth MRI – Devonian Phosphates: Ryan Clark: USGS

Earth MRI – Pennsylvanian High Alumina Underclays: Ryan Clark: USGS

Evaluate the Recent Drawdown in the City of Fort Dodge Jordan Production Wells and the Potential Well Interference from other Water Users: Mike Gannon: City of Fort Dodge

Evaluating a Two-Stage Roadside Ditch Design to Improve Environmental Performance: Keith Schilling: Iowa Department of Transportation (IDOT)

Evaluating the Combined Effects of N Application with and without Manure on Groundwater Quality using a Paired Field Design at the Kirkwood Community College Farm: Keith Schilling: Iowa Department of Agriculture & Land Stewardship (IDALS)

Evaluating the Potential for Drainageways at the Kirkwood Community College Farm to Serve as Test Sites for Innovative Grass Waterway Designs: Keith Schilling: INRC

Evaluating the Relation of Total Phosphorus to Turbidity during High Flow Events to Improve Quantification of Phosphorus Export from Iowa Rivers: Keith Schilling: INRC

Evaluating the Water-Quality Benefits of Reconstructed Multi-Purpose Oxbows: Keith Schilling: INRC

Foundations for the Future: Developing Digital Striplogs and Assessing Critical Mineral Potential: Jason Vogelgesang and Richard Langel: USGS

Geologic Hazards Mapping: Identifying Sinkholes and Karst Susceptible Areas in Worth, Cerro Gordo, Mitchell, and Floyd Counties: Stephanie Tassier-Surine: IDOT

Geologic Mapping in Iowa FY2020–STATEMAP Supplemental Proposal: Stephanie Tassier-Surine: USGS

Geophysical and Evaluation Services at the "Johnson Shaft" Coal Mine Site in Story County, Iowa: Jason Vogelgesang: Hunziker & Associates, Inc.

Geophysical and Evaluation Services near Eddyville, Iowa: Jason Vogelgesang: IDOT

Geophysical Imaging Services at the Harlan Wellfield, Harlan, Iowa: Jason Vogelgesang: Harlan Municipal Utilities

Geophysical Imaging Services at the Iowa Lakes Regional Water Property near Spencer, Iowa: Jason Vogelgesang: Iowa Lakes Regional Water

Groundwater Model for Mason City, Iowa, Quarry Expansion: Mike Gannon: Lehigh Hansen, Inc.

Groundwater Model for Moscow, Iowa, Quarry Expansion: Mike Gannon: Wendling Quarries, Inc.

Groundwater Model for Quarry Expansion: Greg Brennan: Linwood Mining and Minerals

Hydraulic Testing of Select NGWMN Wells by the Iowa Geological Survey: Richard Langel: USGS

Impaired Watershed Mapping in Benton County, Iowa: Surficial Geologic Map of Benton County: Stephanie Tassier-Surine: USGS

Impaired Watershed Mapping in Benton County, Iowa: Surficial Geologic Maps of the Van Horne and Keystone South Quadrangles: Stephanie Tassier-Surine: USGS

Investigating Basin-Wide Goals for Water Quality Improvement and Flood Mitigation: Keith Schilling: Environmental Defense Fund

Oil, Gas, and GeMS: Core Accessibility and Map Standard Updates: Richard Langel: USGS

Financials

Quantifying the Effectiveness of a Saturated Buffer to Reduce Tile Nitrate Levels in Eastern Iowa: Keith Schilling: IDALS

Regional Initiative to Accelerate CCUS Deployment in Midwestern and Northeastern USA: Ryan Clark: U.S. Department of Energy

Seismic Monitoring Services at the NNG Redfield Facility: Jason Vogelgesang: Northern Natural Gas

Silurian Aquifer Groundwater Exploration and Modeling for the City of Fairfax: Jason Vogelgesang: Hall and Hall Engineers, Inc.

Source Water and Drought Assessment at the Proposed Osgood Wellfield, Palo Alto County: Mike Gannon: Iowa Lakes Regional Water

Supporting Persistent IGS Data Services to the NGWMN – 2020: Richard Langel: USGS

Upper Iowa River Watershed Flood Mitigation Site Characterization Study: Ryan Clark: U.S. Department of Housing and Urban Planning, Shive-Hattery Engineers and Architects, Inc.

Well Siting Study – Mississippian Aquifer, Phase II Geophysics Survey – West and South Target Areas City of Iowa Falls, and East and North Target Areas City of Iowa Falls: Greg Brennan: City of Iowa Falls

Western Iowa Loess Hills Drilling: Matthew Streeter: Northwest A&F University

FUNDING FOR THE Iowa Geological Survey is provided through a combination of sources. A state appropriation provides about 38% of our annual operating budget and has stayed constant over the past few years. The IGS leverages this base funding to obtain support for a diverse portfolio of projects from a variety of funding sources. In 2020–21, these funding sources included local municipalities, state agencies, the U.S. Geological Survey, the Iowa Department of Transportation, and the Iowa Nutrient Research Center, among others. It is noteworthy that the entire 2020–21 operating budget for the IGS was funded by these diverse sources. While we continue to seek outside funding, an increase in our annual state appropriations would allow the IGS to place more focus on regional statewide initiatives that help ensure sustainable water resources for Iowans and provide science-based information to support well drillers, government officials, and individuals. The IGS is always ready to collaborate with new and existing clients on exciting, impactful projects.

FY 2021 $1,807,632

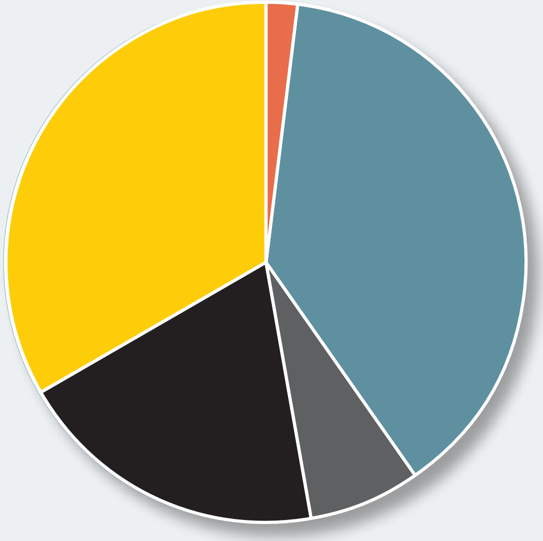
Municipal: City water projects (2%)

State Appropriation: (38%)

INRC: Iowa Nutrient Research Center (7%)

Federal Agency: US Geological Survey, Natural Resources Conservation Service, Environmental Protection Agency, US Department of Energy (19%)

Other: Non-Government contracts, Iowa DNR, Iowa DOT, Iowa Dept of Agriculture and Land Stewardship (33%)



FY2017	FY2018	FY2019	FY2020	FY2021
$1,394,092	$1,450,727	$1,633,533	$1,596,525	$1,807,632

IOWA GEOLOGICAL SURVEY:

130 Years of Service to Iowa


A crew of men at work near lower quarry beds east of Farley, Iowa, in the late 1890s or early 1900s. *Samuel Calvin Photo Collection*


IGS staff members Stephanie Tassier-Surine and Matthew Streeter use the IGS drill rig.

The state of Iowa marked 175 years of statehood on Dec. 28, 2021. Soon after Iowa was admitted into the union in 1846, the governor initiated the first geologic inquiry of the state. James Hall, who also served as Iowa's first state geologist from 1855 until 1858, conducted this survey.

The Iowa Geological Survey did not have consistent funding during the early years, but in 1892, Iowa established a permanent geological survey as a separate agency of state government; the survey continues today under State Geologist Keith Schilling.

In 2014, we became a part of IIHR—Hydroscience and Engineering (IIHR) at the University of Iowa. IIHR was 100 years old in 2020, and a celebration is set for August 2022 (delayed two years after the originally planned festivities, due to the global pandemic). Please join us in wishing the state of Iowa a very happy 175th birthday, and IIHR a slightly belated happy 100th!

An in-depth look at the history of the IGS is available on our website at **https://iowageologicalsurvey.org/igs-history/** .

IGS IOWA 175 YEARS