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BOARD OF REGENTS
STATE OF IOWA

MEMORANDUM

March 30, 2021

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 2019-2020.

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\2021 session\Reports\

Attachments
cc: Ron Robinson
Legislative Liaisons
Legislative Log

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www.iowaregents.edu

the IGS Geode

ACTIVITIES OF THE IOWA GEOLOGICAL SURVEY, 2019–20

Science and Service
FOR IOWANS

IOWA

IOWA GEOLOGICAL SURVEY

The IGS Geode

Activities of the
Iowa Geological Survey
2019–20

ON THE COVER: IGS Soil Scientist Matthew Streeter, Geologist Phil Kerr, and technician Brennan Slater use the IGS drill rig to core through thick loess in western Iowa.

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

WELCOME TO THE 2020 IOWA GEOLOGICAL SURVEY annual report! As a reminder, we've designated IGS *Geode* magazine as the State Geologist's annual report to the state legislature, which is mandated by Iowa Code. Hence, I'm very pleased to submit this annual report for the FY2019–20 year to the Iowa State Legislature!

So, is it just me, or does anyone else feel like 2020 has been a little weird? Just kidding — we are all painfully aware that this has been a year for the ages. Because our fiscal year ends on June 30, I'm technically only supposed to comment on IGS activities that ended before that date, but as we are working on the production of the *Geode* in late fall, we're still under the spell of COVID-19 and the global pandemic.

For the IGS, the pandemic has meant several adaptations made along the way that tested all of us. When the quarantine mandate was issued in mid-March, our fieldwork schedule was starting to kick into high gear to capture the spring runoff season and to begin new mapping initiatives. Fieldwork was then shut down for the next eight weeks or more until safety precautions could be developed, forcing us to halt one project for the year and delay completion of several others. We've managed to adapt to these circumstances and get the work done, but it's been a challenge. Staff have been dutifully working at home while getting to better know our families and the dog at our feet beneath our desk, or in isolation at our laboratory facility. But we're all thinking about how much we'll enjoy the new day when we can work with our colleagues again in person. In the meantime, our thoughts and condolences go out to all those who have been affected by the pandemic.

LEFT: The IGS encouraged the public to bring in geologic curiosities for identification. Here IGS Hydrogeologists Mike Gannon and Greg Brennan help an Independence resident identify something that has perplexed him for a long time.

TOP RIGHT: State Geologist Keith Schilling (right) chats with Iowa Representative Michael Bergan at the Independence outreach event.

LOWER RIGHT: IGS Geologists Ryan Clark and Phil Kerr discuss interesting geologic finds with Independence residents at an outreach event there.

Interestingly, the FY19–20 year began with a lot of promise for social interaction. In late 2019, the IGS held two outreach events in Independence and Bettendorf in eastern Iowa that highlighted IGS history, current status, and projects. Our entire the IGS staff traveled to these events, bringing with them an assortment of posters, rock displays, equipment, and online demos to share with the public. Even the drilling rig made an appearance! We seized the opportunity to highlight IGS projects including geologic mapping, groundwater resources, watershed analysis and water quality, geophysics, and informatics — and, of course, we made time for questions. The outreach events were a wonderful experience for the IGS team, and we all greatly enjoyed meeting those in attendance and chatting about Iowa geology. You can read more about the events and see some photographs on page 4 and scattered throughout this year's *Geode*. Our plan is to hold more of these events in different parts of the state every year, so if you'd like to request a visit by the IGS to your community, please reach out to me. We'd love to come see you!

With such a great start to the year, followed by the downer in the middle part of the year, it is my pleasure to say that the IGS had a very successful end of the year, both in terms of new and ongoing projects completed, but also in terms of our finances. Since our joining the University of Iowa and IIHR—Hydroscience & Engineering in 2014, the IGS has strived to make IIHR's investment in us pay off for everyone involved. With a state appropriation that covers only about one-third of our financial needs, the IGS has been working hard over the years to obtain outside funds through contracts and grants to make up the annual budget shortfall. While I recognize that every year is different (c.f. 2020), it is with great satisfaction that I can say we were able to finally balance our books in FY19–20. On pages 26–27, you can read through the list of new projects obtained by IGS staff and see the incredible diversity of topics and number of different IGS staff involved. The success of the IGS has always been a team effort, and this year was no exception. But for some reason, this feels especially rewarding.

Finally, to the good stuff! Like past years, you'll find a great assortment of articles that highlight IGS projects conducted during the past year. This year, we're highlighting a foundational activity that has been a focus of the survey for 130 years — that is, geologic mapping. In several mapping-related articles, IGS geologists answer the question, "Why is mapping important?" We'll also present some new mapping tools and interesting applications.

Another section highlights IGS's increasing involvement with conservation targeting and water quality. IGS staff work with an assortment of different agencies and organizations to help locate conservation practices where they will do the most good, while also conducting the monitoring to quantify their benefits.

Finally, we highlight other important IGS projects conducted this past year, including new aquifer modeling in Des Moines and northwest Iowa. We are also excited to present a new state park feature article (this year's focus is on Maquoketa Caves State Park).

I hope you enjoy the 2020 edition of the IGS *Geode*, and as always, please feel free to reach out to me or other IGS staff at any time with questions or concerns. You can also contact us through or social media accounts (list at the bottom of the facing page) and please check out our new IGS website at **www.iowageologicalsurvey.org**.

Keith Schilling

KEITH SCHILLING
State Geologist

IGS Launches New Website

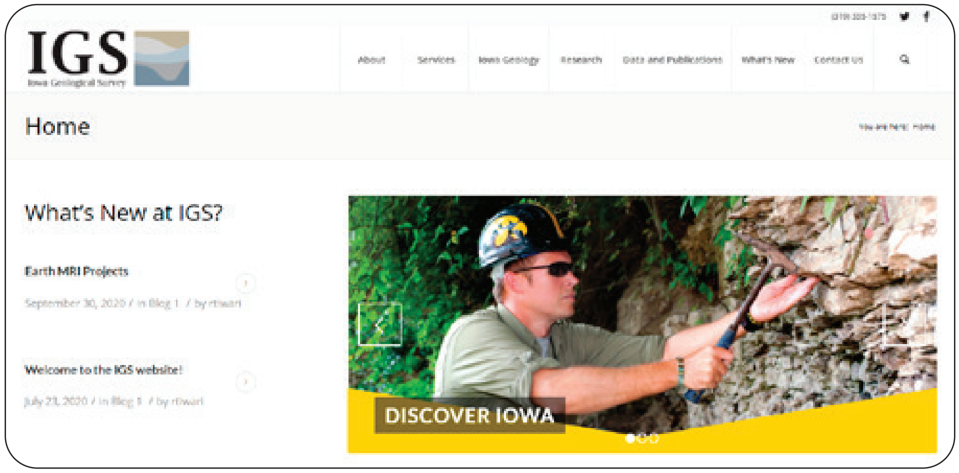
IN JULY 2020, the Iowa Geological Survey launched a new and improved website at **https://iowageologicalsurvey.org**. We updated and organized the site around four main pillars of information: Research, Services, Iowa Geology, and Data and Publications.

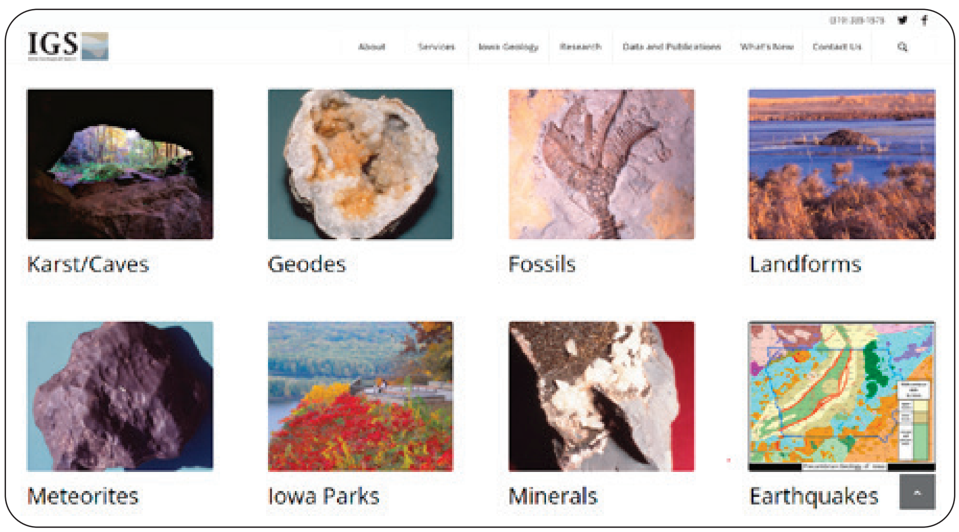
Research has always been an important component of the IGS's work, and the list of publications, reports, and maps produced by IGS staff over the last century is impressive. The IGS is actively conducting applied and foundational research on many topics, and links to many of these project areas can be found under the Research tab.

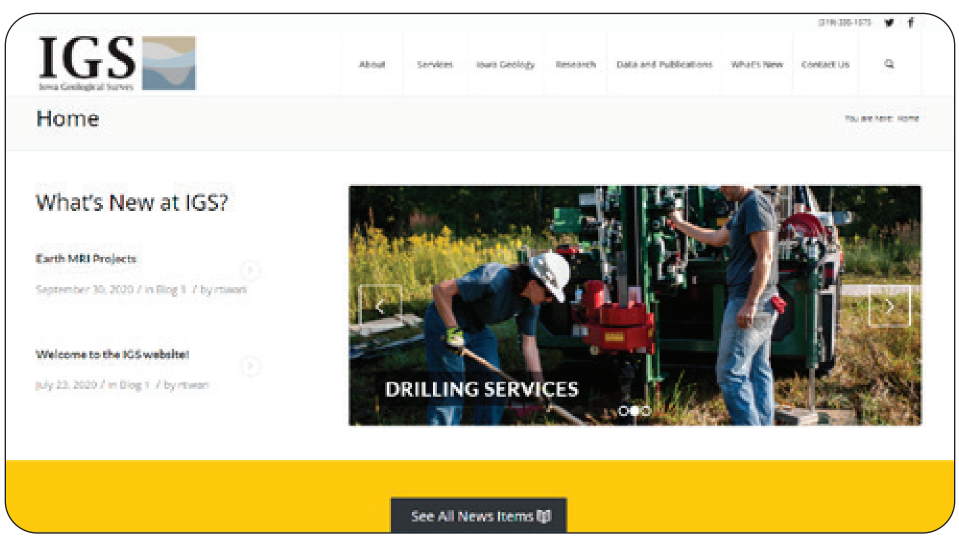
The IGS has been around since 1892, and it has a lot of great general information and Iowa-related publications to share. This information can be found by clicking on the Data and Publications tab, which will introduce you to a series of interactive maps, publications, and databases that can help you dig deeper and learn more about Iowa's geology.

Through the Services tab, the website highlights the availability of the fee-for-service projects the IGS can perform for private clients and government agencies. The IGS possesses advanced expertise, instrumentation, and technical capabilities that can provide critical information to aid planning and decision-making efforts. Popular services include groundwater modeling, geophysical analysis, geologic mapping, drilling, and sediment analysis. We welcome the opportunity to work with clients to meet their individual needs and encourage anyone interested to reach out to the IGS to obtain a quote for services. Email us at **iihr-iowa-geological-survey@uiowa.edu** to learn more, or call 319-335-1575.

We encourage all *Geode* readers to take a closer look at the new IGS website! We look forward to hearing from you if you have any questions, comments, or suggestions.







IGS Hits the Road for Public Outreach

KIDS LOVE ROCKS. All parents and former kids know this is true. Children can spend hours happily sorting, piling, and examining rocks. Deep inside most adults, an inner rock-loving kid survives.

State Geologist Keith Schilling, who leads the Iowa Geological Survey, says the proof of this can be seen every time the IGS holds a public outreach event. “Everybody seems to come at it from a personal level,” Schilling says. “Everybody’s got a story. That is what really drives the conversation.”

The IGS hosted two public outreach events in late 2019 that demonstrated this widespread love of rocks. The entire IGS team traveled to Independence on Nov. 19 and to Bettendorf on Nov. 22, bringing with them an assortment of posters, rock displays, and online demos. Short presentations highlighted IGS projects including geologic mapping, groundwater resources, watershed analysis and water quality, geophysics, and informatics, with time for questions. Some of the topics that generated the most interest were sinkholes, sand and gravel operations, and water quality.

Of course, there just wasn’t enough time to answer all the questions, Schilling says. He had to cut the conversation short because it was time to vacate the room.

“We love to hear from the public,” Schilling says. Often these discussions can influence decisions on future IGS projects and mapping efforts. And it helps to keep everyone motivated.

“We all left feeling jazzed up a little bit about the interest,” Schilling says. “We found it to be a hugely rewarding experience.”

Schilling and his team are anxious to hit the road again as soon as they can safely do so. Public outreach is an important part of the IGS mission—and it’s fun!

If you’re interested in hosting a post-COVID-19 IGS outreach event in your community, please contact us at **iihr-iowa-geological-survey@uiowa.edu** or call 319-335-1575.

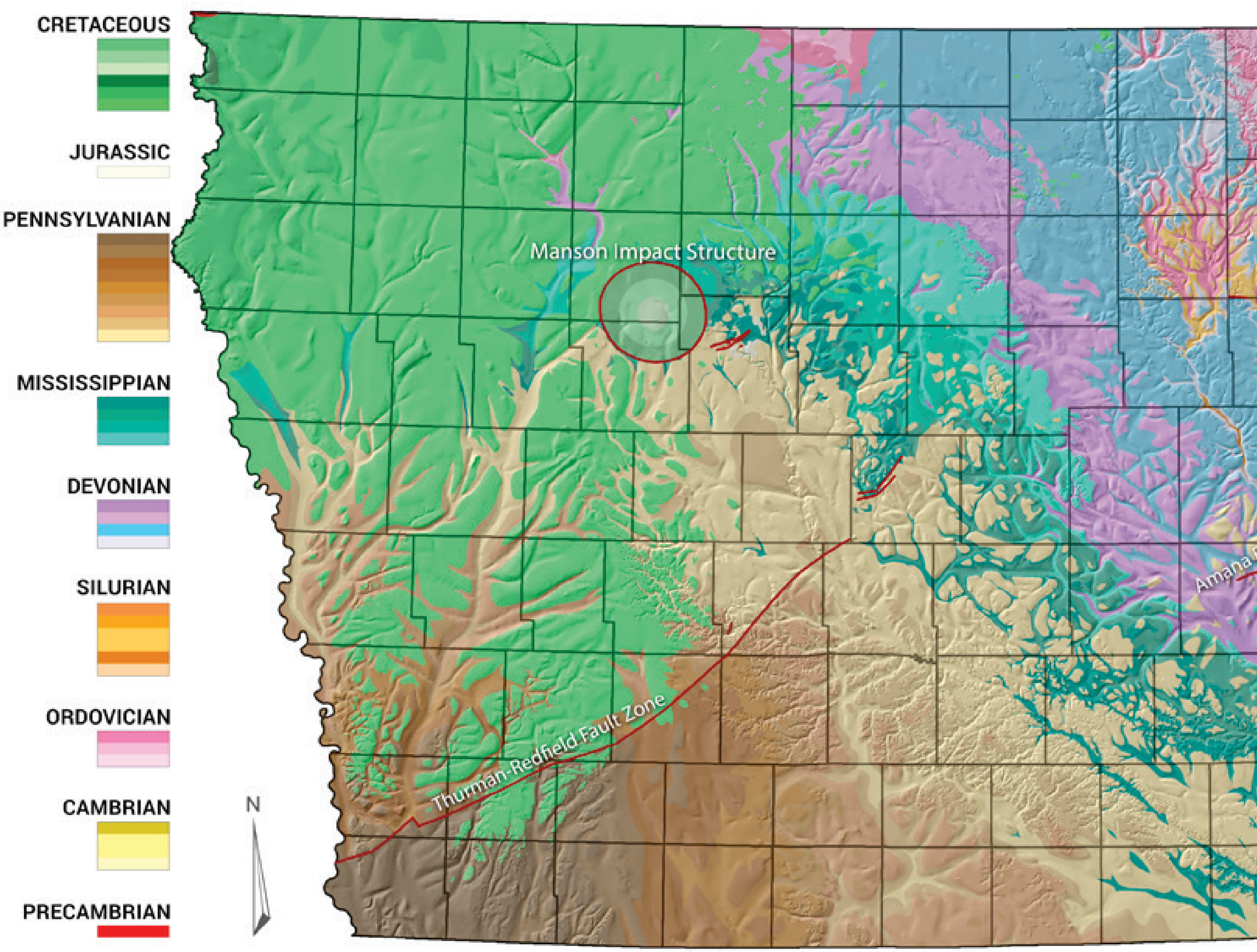
The IGS’s Rick Langel (left) and Jason Vogelgesang (right) talk with a local resident.

The IGS’s Stephanie Tassier-Surine and Jason Vogelgesang.

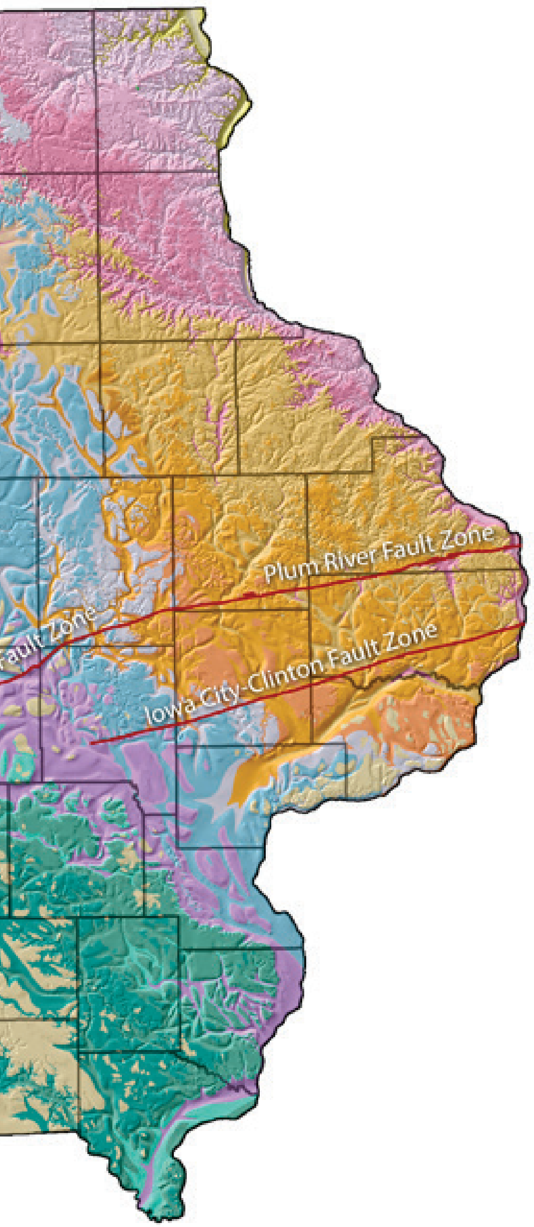
Geologic Mapping in Iowa

Addressing Societal Prob

By Stephanie Tassier-Surine and Ryan Clark



lems with Maps



GEOLOGIC MAPPING has been a fundamental activity of the Iowa Geological Survey (IGS) since its inception. A geologic map is a tool designed to inform users about what lies on or below the land surface. Maps can incorporate a wide range of information, including the organization of geologic units (stratigraphy), the distribution and thickness of units, lithologic characteristics (rock type, fossils, structures), horizontal and vertical variability, and correlation of units over large areas.

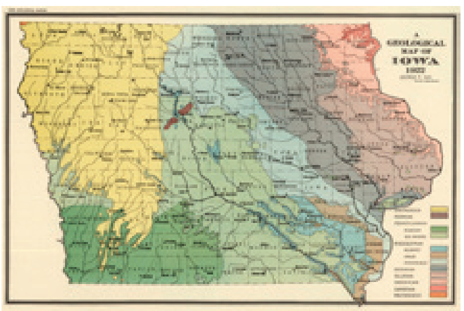
The earliest geologic studies in Iowa focused on resource potential (limestone aggregate, coal, minerals). The first geologic investigation of Iowa began in 1839 when David Dale Owen was commissioned to conduct a survey of Iowa, Wisconsin, and Minnesota. This work culminated with the first geologic map of Iowa in 1852. Most early IGS publications, particularly the county reviews in the Annual Reports, used maps to disseminate geologic information.

IGS geologists use numerous resources when creating a geologic map. The IGS GeoSam database is an online catalog of over 90,000 drilling records. Although most records are paper drilling logs, about 40,000 also include drill cutting samples. More than 23,000 of those have been studied by geologists creating strip logs (a graphic illustration of the geologic materials encountered). The IGS core repository also houses 1,300 rock cores totaling 150,000 feet. When possible, the IGS also collects additional core, visits outcrop and quarry sites, collects laboratory data, and employs geophysical methods to improve our understanding of the geologic units and their relationships in a given area.

The IGS has participated in the U.S. Geological Survey's (USGS) STATEMAP

GEOLOGIC MAPS EVOLVE over time, not only because of advancements in mapping techniques, but also through dedicated research. Since the late 1800s, the IGS has produced maps of various scales to communicate the complexities of Iowa's bedrock and surficial geology. Each map reflects the improved understanding gained since the previous edition.

BEDROCK GEOLOGIC MAPS published by the Iowa Geological Survey in 1894, 1922, and 1969 (top to bottom). The progression of the maps illustrates the increased understanding of the bedrock geology of Iowa though time, as well as improvements due to an increase in available data at the time of their production.



The earliest geologic studies in Iowa focused on resource potential (limestone aggregate, coal, minerals).

program since 1993. The USGS awards funding to state surveys under a competitive grant program with a 50:50 match requirement. The state surveys choose projects in consultation with an advisory committee of public and private stakeholders, with preference given to areas that have both societal and scientific merit. Under this program, the IGS has received over $3.7M in federal grant funding and produced more than 150 geologic maps, including both surficial and bedrock maps at quadrangle (1:24,000) and county (1:100,000) scales.

Work completed under the STATEMAP program also led to the current Bedrock Geologic Map of Iowa (Witzke et al., 2010). This map was a significant improvement over the previous version published in 1969 and was the first to be constructed using geographic information system (GIS) technology. Our geologic maps have been used by local, county, and state officials, as well as private entities, to address questions related to groundwater vulnerability, aggregate resources (both protection and sourcing), urban expansion, hazard potential, and land use planning. The IGS also produces derivative maps, in which geologists can combine many data sources to produce a map that directly addresses a particular need. A recent project funded by the Iowa Department of Transportation (IDOT) Highway Research Board was designed to identify the locations of sinkholes and other features related to karst geology in Worth, Cerro Gordo, Mitchell, and Floyd counties in north-central Iowa. Although sinkholes are often identified during county soil surveys, our initial assessment more than doubled the number of mapped depressions in the four-county area. This work will significantly increase our understanding of where sinkholes occur and result in maps that will inform the IDOT of where sinkholes may occur in the future. A karst susceptibility map will allow the IDOT to make informed decisions when planning future transportation projects, thus ensuring the long-term viability of vital roadways.

If the IGS had not already constructed detailed maps of the surficial and bedrock geology of the four-county area as part of the STATEMAP program, this endeavor would not have been possible. This project illustrates why geologic mapping is vital to our efforts to solve societal issues. Identifying geologic hazards through various mapping techniques has the potential to save money on avoidable infrastructure repairs and improve the safety of Iowa's roadways.

Geologic maps often have many unanticipated uses. In 2011, a bedrock geologic map of the Upper Iowa River Watershed (UIRW) was completed in a combined effort between the STATEMAP program and the Iowa 319 Nonpoint Source Pollution Program. The original intent was to assess the degree to which surface contaminants affect bedrock aquifers and surface water bodies. However, a new hazard became apparent years later — flooding. Addressing the results of heavy rainfall events in a dynamic watershed required extensive knowledge of the subsurface. The UIRW Management Authority had selected best management practices, such as retention basins, to slow the flow of surface water runoff. Installing stormwater retention structures in areas of karst geology proved to be tricky and, once again, the detailed geologic map of the UIRW proved useful to guide where these vital structures would work best.

The UIRW geologic map and its associated mountain of data helped solve yet another societal issue in northeastern Iowa — frack sand mining. As the practice of hydraulic fracturing (fracking) of shale deposits in oil fields across the United States ramped up, the need for specific sandstone deposits increased dramatically. The St. Peter Formation is an ideal source for frack sand in the upper Midwest and it occurs near the land surface within the UIRW. The Winneshiek County Board of Supervisors consulted with the IGS numerous times about the effects of mining the St. Peter Formation in their area. Luckily, the UIRW geologic map had all the information they needed to make informed decisions to regulate this emerging industry.

Des Moines Metropolitan Area Groundwater Sustainability Project

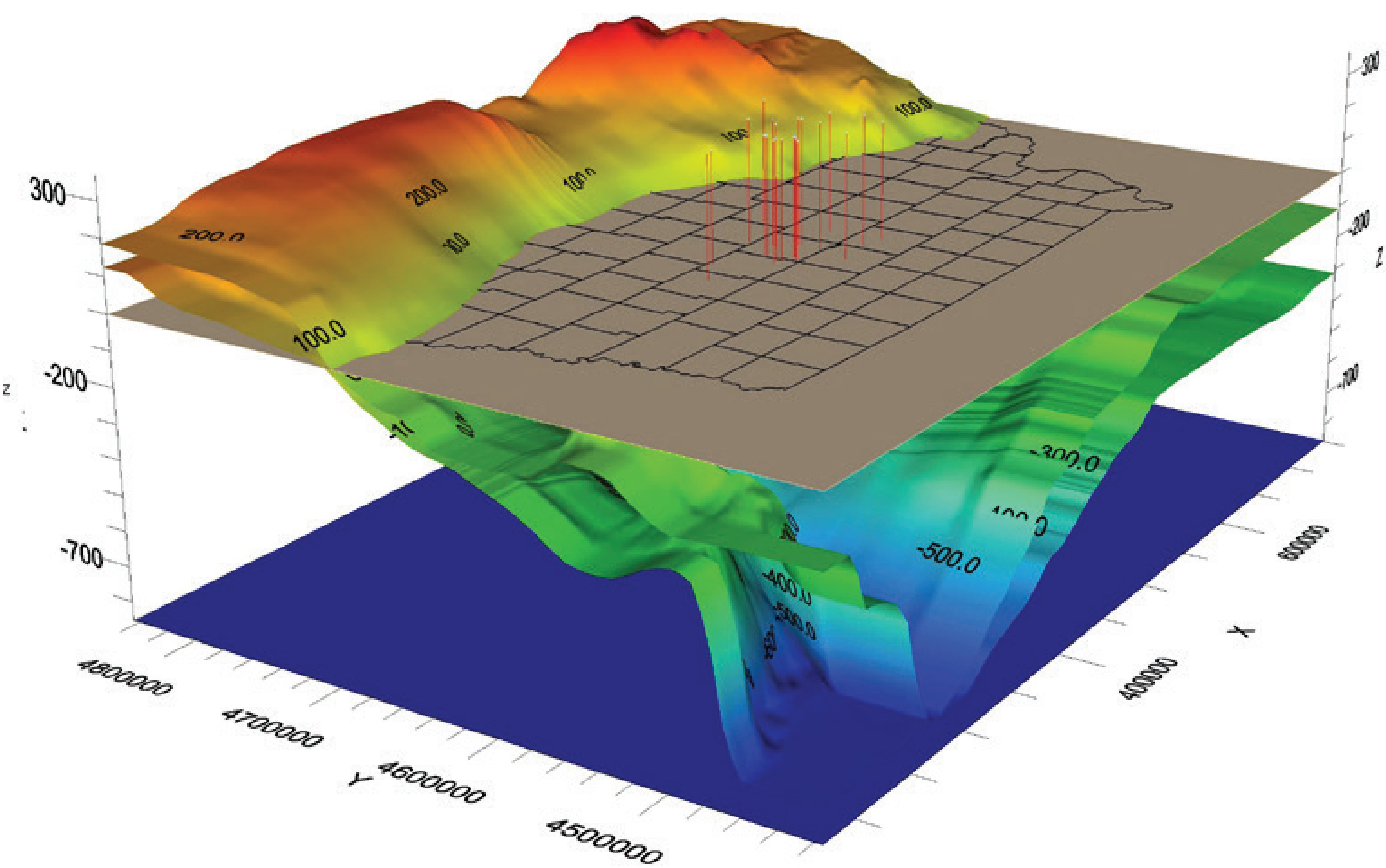
By Mike Gannon and Greg Brennan

SEVERAL PUBLIC WATER UTILITIES in the Des Moines Metropolitan Area (DMMA) hired the Iowa Geological Survey (IGS) to investigate the long-term sustainability of the Cambrian-Ordovician (CO) aquifer. The DMMA is the fastest growing metropolitan area in Iowa, with projected population growth expected to top 1 million by 2030, and water usage expected to grow by approximately 40–50%. The IGS collaborated closely with the Iowa Department of Natural Resources (IDNR) to study the aquifer.

IGS hydrologist Mike Gannon and hydrogeologist Greg Brennan used a calibrated groundwater flow model to evaluate current and allocated water usages for the CO aquifer in the DMMA. Model results suggested that users in the DMMA would remain comfortably above regulatory levels after 20 years if current usage and infrastructure were maintained. We calculated the pumping water levels by averaging the winter and summer water levels at each well, which sometimes varied by 50–150 feet or more. This water-level variability is caused by the injection versus pumping cycles of the DMMA aquifer storage and recovery (ASR) wells. Each ASR well pumps approximately 3 million gallons per day (mgd) for three months in the summer; in the winter, each well injects 1.1 mgd for the remaining nine months. Water managers use ASR wells extensively in the DMMA during the summer peak water demand period. These wells are also used to blend with river and alluvial water sources to reduce nitrate concentrations.

In the optimum water-use scenario, the IGS team assumed that Grimes, Tyson Meats, West Des Moines, and Altoona would each add one new production well. The proposed West Metro Water District would add nine new ASR wells; Des Moines Water Works would add three; and Ankeny would add two.

Modeling results indicate that additional capacity for CO aquifer expansion exists in the DMMA. However, care should be taken in permit renewal, and water levels should be evaluated over the five-year permit period to verify that each production well remains in regulatory compliance.



THREE-DIMENSIONAL IMAGE of the Cambrian-Ordovician aquifer showing the Des Moines area wells used in the Visual MODFLOW groundwater model.

Assuring a Safe and Dependable

By Mike Gannon and Greg Brennan

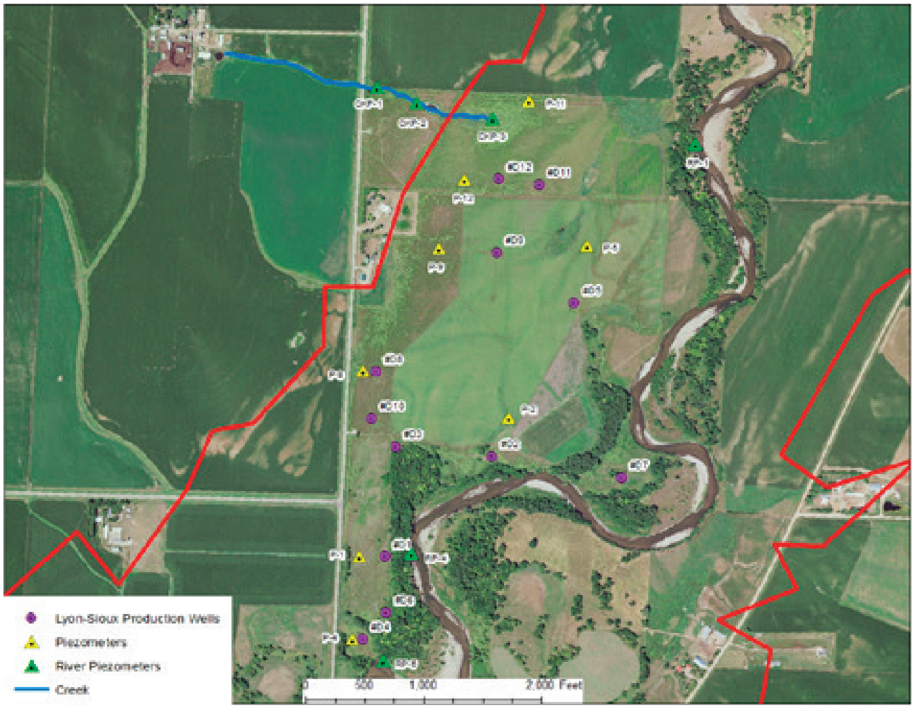


FIGURE 1: Lyon-Sioux Rural Water Doon Wellfield.

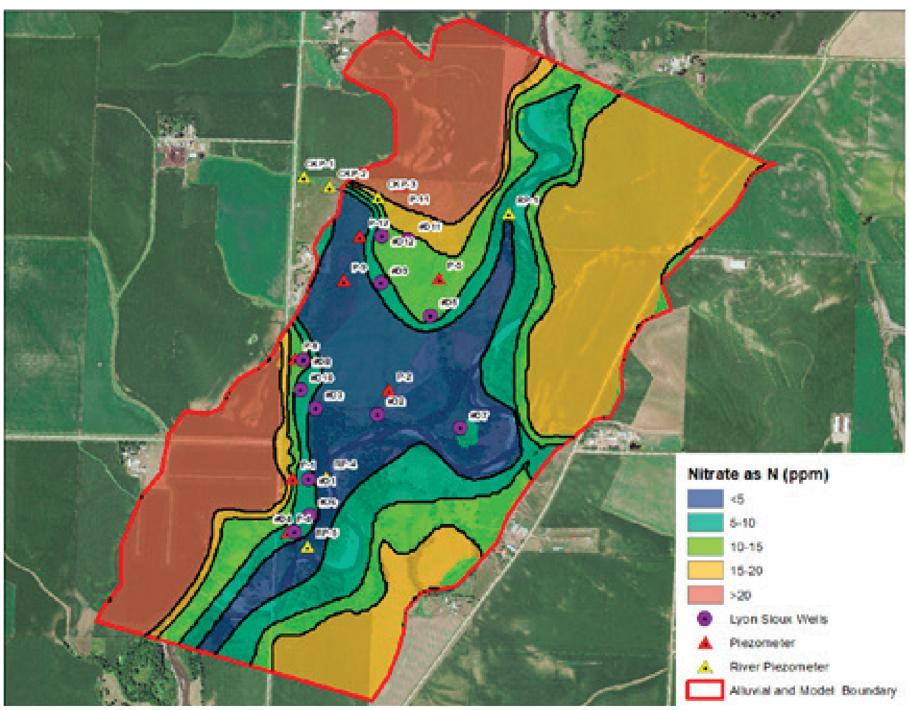


FIGURE 2: Nitrate Distribution in the LSRW Wellfield and surrounding area.

THE LYON-SIOUX RURAL WATER SYSTEM (LSRW) provides over a billion gallons of drinking water annually to nearly 2,000 rural users, multiple livestock producers, and seven communities in northwest Iowa. The Rock River alluvial aquifer wellfield supplies the Doon Subsystem. This wellfield consists of 12 production wells in an area of about 250 acres located about a mile upstream of the city of Doon in Lyon County, Iowa (Fig. 1).

Over the past several years, LSRW officials have observed increasing nitrate concentrations in many of their production wells. In 2019, they hired the Iowa Geological Survey (IGS) to complete a source water assessment of the Doon wellfield. The purpose of the assessment was to characterize the hydrologic properties of the aquifer, to develop and calibrate a groundwater flow model to identify nitrate sources and pathways, and to develop conservation strategies to mitigate nitrate impacts.

The results of the assessment showed several sources of nitrate affecting the LSRW production wells. The nitrate concentration distribution (as nitrogen) in the shallow groundwater is shown in Fig. 2. The highest concentrations — more than 20 ppm — are found in corn acreage to the north and west of the wellfield. The groundwater flows toward the south and southeast, creating nitrate plumes that impact production wells D-11, D-12, D-5, D-9, D-8, D-1, and D-4. Nitrate concentrations in production wells D-2, D-3, and D-7 are at less than 5 ppm, likely due to the nitrate reduction benefits provided by prairie grass, and to a lesser extent the lower nitrate concentrations associated with the induced recharge from the Rock River. IGS researchers used particle tracking data in the model to quantify the percentage of each nitrate source affecting the individual wells.

The small creek (Fig. 1) is another significant source of nitrate. Researchers measured nitrate concentrations of between 15–25 ppm in samples collected from this creek. The creek flows at the ground surface for approximately 800 feet onto the floodplain. East of this point, the surface water completely recharges into the sand and gravel aquifer and disappears from the land surface. Nitrate from the creek impacts production wells D-11 and D-12 (Fig. 2).

Based on the model results from the source water assessment, the IGS researchers identified potential conservation practices to reduce the nitrate concentrations in the water supply at LSRW (Fig. 3). These include the following:

1. Cover crops in the row crop acres to the north and west of the wellfield
2. Riparian buffers along the north and west sides of the wellfield
3. Additional wetland plantings near the terminus of the creek
4. Cover crops in the watershed of the small creek

Cover crops planted in a portion of the corn acreage to the north and west of the wellfield would help to reduce a major source of nitrate before the groundwater reaches LSRW.

Cover crops planted in the row crop acres within the creek's watershed might help reduce the nitrate concentrations in the creek, which recharges shallow groundwater in the northern portion of LSRW.

A secondary nitrate reduction strategy involves planting riparian buffers (trees and shrubs) along the north and west sides of the LSRW wellfield property. These buffers will intercept and further reduce nitrate concentrations in groundwater migrating onto the wellfield (Fig. 2). The root zones of these trees and shrubs reduce nitrate concentrations in the deeper groundwater (10 feet deep or more); riparian buffers complement the existing nitrate reduction produced by the prairie grass. It will take a minimum of 3–5 years for the trees and shrubs in the riparian buffers to reach an appropriate size and root depth to cause their full impact on reducing nitrate concentrations in the groundwater.

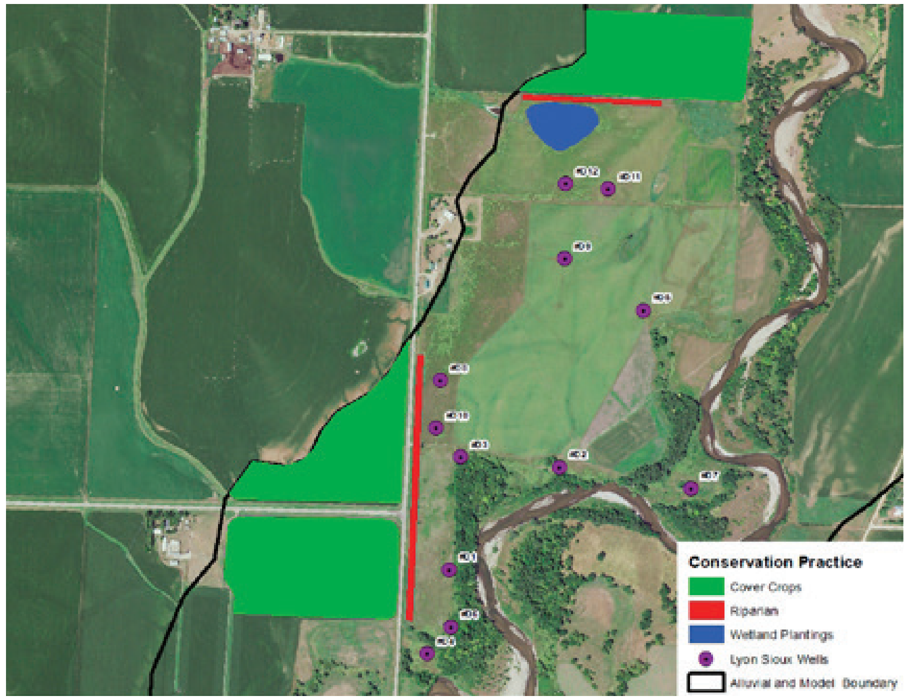


FIGURE 3: Proposed conservation practices to mitigate nitrate concerns at LSRW.

DAVE HARMSEN of LSRW holds a newly planted tree along the west side of the wellfield.

New Technology Improves Su

By Jason Vogelgesang

DETAILED GEOLOGIC DATA are often hard to gather at field sites because the area being studied is underground and buried from view. As any geologist knows, actual subsurface conditions can often vary widely, and connecting the dots between sampling points is fraught with potential error. At the Iowa Geological Survey (IGS), we are embracing new technology to help us characterize project sites and improve mapping, and to incorporate these into groundwater flow models. The Electromagnetic Terrain Conductivity Meter, or EM, is one piece of geophysical equipment being used by the IGS to rapidly survey project sites and increase the accuracy of project results.

Ground conductivity is directly correlated to subsurface geologic composition. Sandy sediments resist electrical charge and have low conductivity, whereas clay and silt-rich sediments have higher ground conductivity. This is important in many parts of Iowa, especially near rivers, where sandy soils are intertwined with clay and silt-rich soils. Farmers know that crops grown in areas underlain by sand are well-drained and must receive frequent water to keep them hydrated. Since water travels through these coarse sediments much faster than it does through fine sediments, knowing the conductivity at the field-scale can provide immense benefits to shallow groundwater and crop-based studies.

We use an EM-31MK2 (Geonics Ltd.) mounted to an all-terrain vehicle for rapid acquisition of ground conductivity data, even in large fields (Fig. 1). While the EM-31 has been used for several decades, primitive use of the unit involved holding the equipment above the ground and pressing a button to gather one measurement. Now, we can mount the unit to an all-terrain vehicle and collect continuous readings — several per second — while traveling at approximately 5 miles per hour. Instead of gathering a few measurements at a site, we can now collect tens of thousands of measurements in just one day's work.

Figure 2 presents results from a recent EM study completed by Jason Vogelgesang at a cropped field at Kirkwood Community College in Cedar Rapids, Iowa. The colors show how conductivity varies at the site, with warm colors representing high conductivity (fine-grained sediments) and cool colors showing low conductivity (coarse-grained sediments). A stark contrast was seen in this field, with a clear division of sand and glacial till trending in a rough southwest to northeast orientation. Monitoring wells installed with the IGS drill rig for the project confirmed the striking sediment changes but, interestingly, there was no surface expression of the geologic differences observed in shallow soils. When we sampled the wells, we found that the subsurface variations greatly influenced the groundwater quality. Groundwater in the fine-textured till had a significantly higher water table and higher specific conductance from dissolved phosphorus, while groundwater in the sand aquifer had a deeper water table as well as higher NO3-N and dissolved oxygen concentrations.

Overall, the final project results showed that geologic composition heavily affected the groundwater conditions. In addition, accurately mapping subsurface variations using the EM survey was instrumental in making sound interpretations.

Other investigations using the EM have been completed, are in progress, or are planned for completion by the IGS. The EM unit penetrates a maximum of 20 feet below the ground surface, allowing collection of high-resolution data to assist with shallow groundwater, farm-field, or soil investigations.

FIGURE 1: EM-31 mounted to an all-terrain vehicle.

bsurface Data Collection

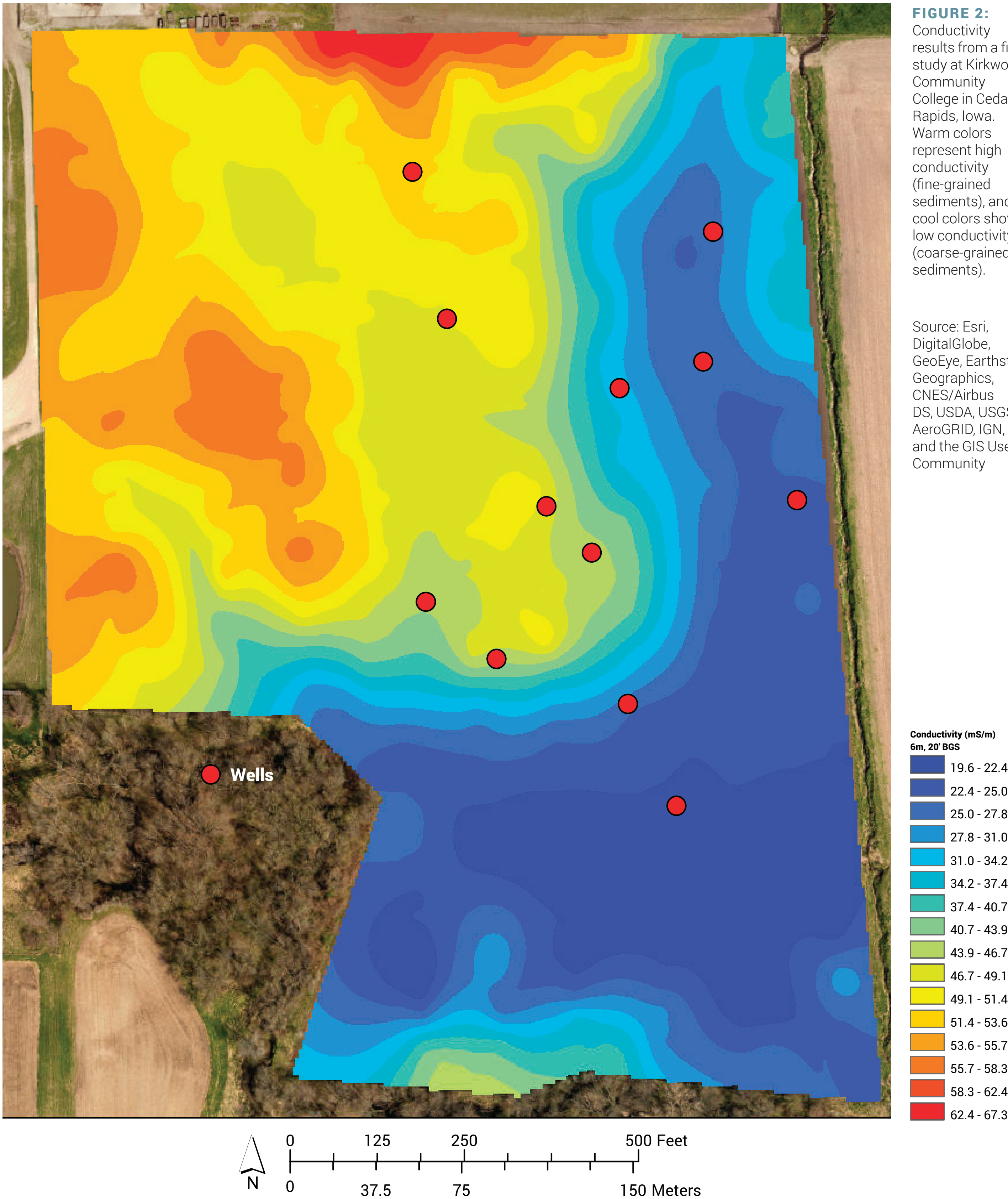


FIGURE 2: Conductivity results from a field study at Kirkwood Community College in Cedar Rapids, Iowa. Warm colors represent high conductivity (fine-grained sediments), and cool colors show low conductivity (coarse-grained sediments).

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

By Stephanie Tassier-Surine and Ryan Clark

Portable XRF Enhances Geochemical Surveys

The handheld pXRF unit can be used in either the laboratory or the field to rapidly analyze rock cores, hand specimens, or even *in situ* outcrops.

THE PORTABLE X-RAY FLUORESCENCE (pXRF) analyzer is a remarkable tool for collecting elemental data in a fast and easy manner. X-ray fluorescence is an analytical technique that uses an x-ray beam focused onto a surface, where it causes electrons to excite, or fluoresce. The pXRF unit analyzes the resulting spectral emission to determine the concentration of each element present in the sample.

The handheld pXRF unit can be used in either the laboratory or the field to rapidly analyze rock cores, hand specimens, or even *in situ* outcrops. This method is non-destructive and detects more than 30 elements in a matter of minutes. However, in some cases, a homogeneous sample is required in which the material is ground into a fine powder and pressed into cups prior to analysis. The University of Iowa Department of Earth and Environmental Sciences (UI-EES) has two pXRF analyzers and has been graciously allowing the Iowa Geological Survey to use them for a variety of applications.

The IGS recently analyzed 70 Pennsylvanian underclay samples and 102 Devonian phosphate samples as part of the U.S. Geological Survey (USGS) Earth Mapping Resources Initiative (MRI) program to identify the presence of critical minerals. IGS geologist Ryan Clark conducted the sample collection and selection, while a UI-EES student intern performed the pXRF analyses. Results may lead to future geologic mapping projects in the state.

IGS geologist Stephanie Tassier-Surine has also used the pXRF unit to analyze Quaternary deposits, primarily glacial till. Traditional methods for differentiating stratigraphic units in the glacial record include clay mineralogy, pebble lithology, and grain-size distribution. These techniques are labor intensive and time consuming. The pXRF allows us to quickly analyze samples to determine which geologic unit is present.

In addition, IGS researchers Keith Schilling and Matthew Streeter have used the pXRF to study the metal concentrations in soil samples collected from roadside ditches. Researchers compared elemental concentrations of ditch samples with adjacent upland samples to evaluate the impact of road salt application, the composition of highway aggregate, the presence of elements from catalytic converters (via automotive exhaust), and the redeposition of eroded soils from the uplands.

The pXRF has proven to be a valuable addition to the IGS toolbox by expanding our research and analytical capabilities.

IGS Geophysics Investigations Help Prevent Highway Hazards

By Jason Vogelgesang and Phil Kerr

HIGHWAYS AND SINKHOLES don't mix! The IGS recently investigated the condition of bedrock along a roadway managed by the Iowa Department of Transportation (Iowa DOT). The purpose of the work was to evaluate potential karst hazards using geophysics and drilling at a site in north-central Iowa.

The IGS's Jason Vogelgesang, Phil Kerr, and Greg Brennan conducted electrical resistivity (ER) and electromagnetic terrain conductivity (EM) geophysical surveys to image the surficial and bedrock characteristics at the site. The results helped identify current and developing karst hazards and/or large voids present in carbonate rock. Karst-related voids, such as sinkholes, filled with soil or other surficial materials, can be anomalously conductive when compared to the surrounding rock, which is generally resistive. Additionally, subsurface moisture and groundwater can affect the resistivity of materials and the development of sinkholes.

Geophysical results, confirmed by drilling, show that the site has complex geology. The bedrock consists of shale and carbonate of the Lime Creek and Shell Rock formations. The general surficial geology in the study area can be described as reworked till over shale toward the western edge; and eolian sand over glacial till, sitting on shale, was observed near the eastern section. The central area has eolian sand atop coarse sand and gravel, directly over carbonate bedrock. This shale gap at the center of the study area indicates this unit was removed during or before deposition of the sand and gravel. Consequently, most of the boreholes located in the thick sand areas were dry, indicating that the water table was below the bedrock surface. However, a perched water table – groundwater that is locally higher due to an impermeable layer – was encountered near one end of the site. The perched water is within reworked till and is likely due to the presence of underlying shale above the carbonate rock.

The investigation concluded that future sinkholes are likely to be concentrated in an area overlain by sandy sediments, which allow surface water to migrate into the karst-prone limestone. Areas with shale or till above the carbonate bedrock may still have voids within the carbonate rock; however, the increased competency of the overlying materials would greatly impede the formation of sinkholes in the area.

Iowa DOT is closely monitoring the site for future karst activity.

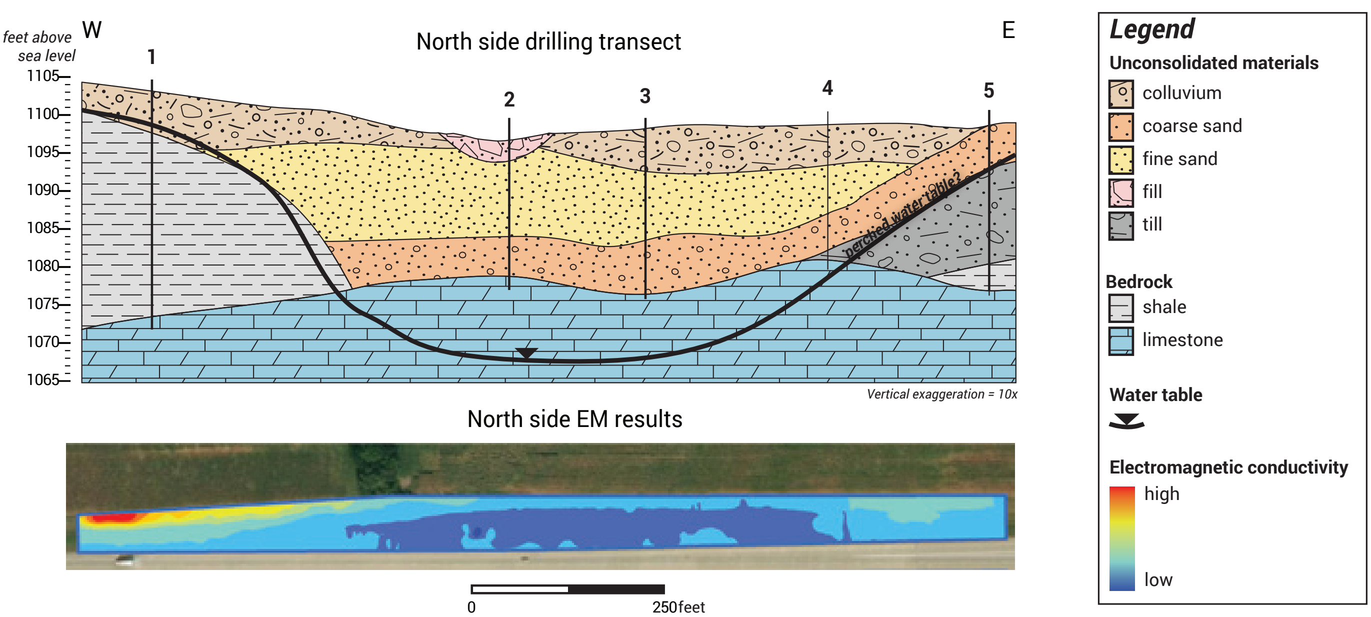
DID YOU KNOW?

The IGS collects approximately **49,000 feet** of ER geophysical data per year (**over 9 miles!**).

IGS staff pounded approximately **22,000 electrode stakes** into the ground in the last decade.

If all ER data collected by the IGS in the last 10 years were represented by a continuous line, it would stretch nearly **from Des Moines to Iowa City**!

A SCHEMATIC geologic cross-section (top) and electromagnetic terrain conductivity geophysical results (bottom) from the north side of the site.



IGS Research Supports Water

In an agricultural state such as Iowa, conservation practices are needed to reduce the impacts of nonpoint source pollution and flooding on surface and groundwater resources. The Iowa Geological Survey has partnered with several state and federal agencies to gain a better understanding about where conservation practices should be located within watersheds and to help quantify the effectiveness of these practices once they have been installed.

In this series of articles, you will see examples of how the IGS is working with local, state, and federal partners to improve water quality in Iowa.

Quality in Iowa

How Effective are Saturated Buffers?

By Matthew Streeter

IN 2019, IGS SCIENTISTS Keith Schilling and Matthew Streeter began a two-year research project in eastern Iowa to study the effectiveness of a new agricultural conservation practice for nutrient reduction and improvement of stream water quality, the "saturated buffer" (Fig. 1).

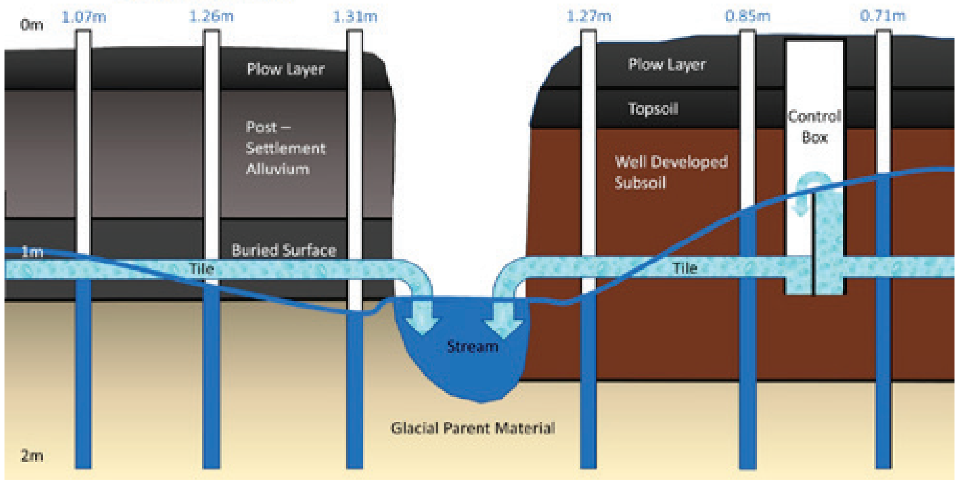
Saturated buffers intercept tile drainage water from agricultural fields and divert it into grassed buffers near perennial streams. A drainage tile control box permits managers to force tile water to back up, thereby raising the shallow groundwater table of the buffer. The newly saturated soil environment allows anaerobic bacteria to convert nitrate in groundwater to nitrogen gas, which is incorporated into the atmosphere by a process known as denitrification. Previous research on saturated buffers has focused on the Des Moines Lobe of north central Iowa and has not considered the effectiveness of this practice in eastern Iowa, where the steep eroded landscape is comprised of loess-capped summits and weathered glacial subsoil.

The team installed shallow groundwater monitoring wells in the area of the buffers to compare groundwater passing through the saturated soils, water flowing directly from a tile drain, and water from the flowing stream. They also comprehensively characterized the soils and subsoil features in the study area using soil core sampling and geophysical investigations.

Preliminary results from the study were quite compelling. Nitrate levels in wells where a saturated buffer had been installed were significantly lower than nitrate levels in the drainage tile or stream water (Fig. 2). Additionally, soil sampling and geophysical investigation results in the study area revealed significant differences in the parent material of the saturated buffer when comparing one side of the stream to the other. While one side of the stream was derived primarily of post-settlement alluvial sediment, the other side was found to have a well-developed glacial derived subsoil. Interestingly, both parent materials performed well at reducing nitrate levels from tile water.

These results provide a compelling argument for large-scale implementation of saturated buffers in Iowa.

FIGURE 1 Average Depth to Water



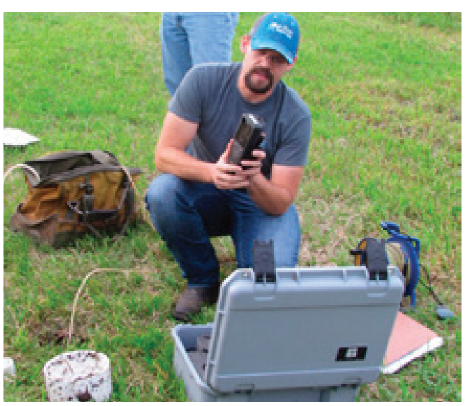
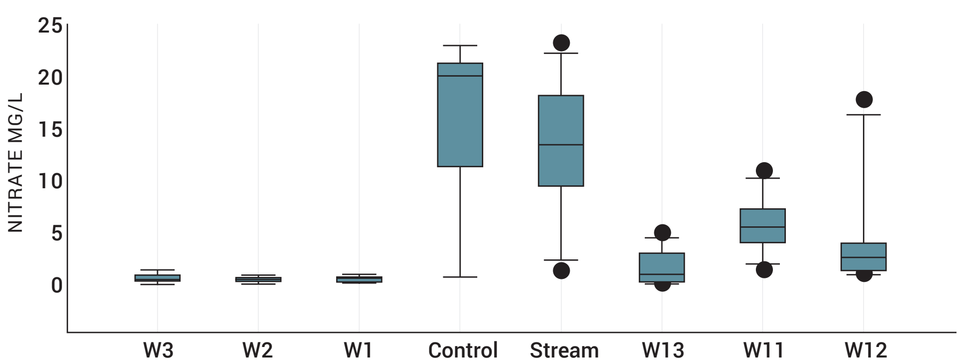


FIGURE 2



Targeting Conservation Practices: IGS Evaluates Nutrient Export from a Cropped Field to Stream

by Keith Schilling

IN 2018, IGS DIRECTOR Keith Schilling led a team of researchers conducting a monitoring study of an intensively cropped field typical of farms in north-central Iowa. The team, which included IGS scientists Matthew Streeter and Jason Vogelgesang, received funding from the Iowa Nutrient Research Center.

Throughout the region, soluble nutrients consisting of nitrate (NO3-N) and orthophosphorus (OP) are routinely discharged from cropped fields to streams through subsurface tile drainage and groundwater seepage. However, the relative contribution of each has not been well quantified. This two-year study was designed to assess the relative nutrient load contributions from both sources to a local perennial stream and to estimate the effectiveness of potential edge-of-field conservation practices to reduce their loading inputs.

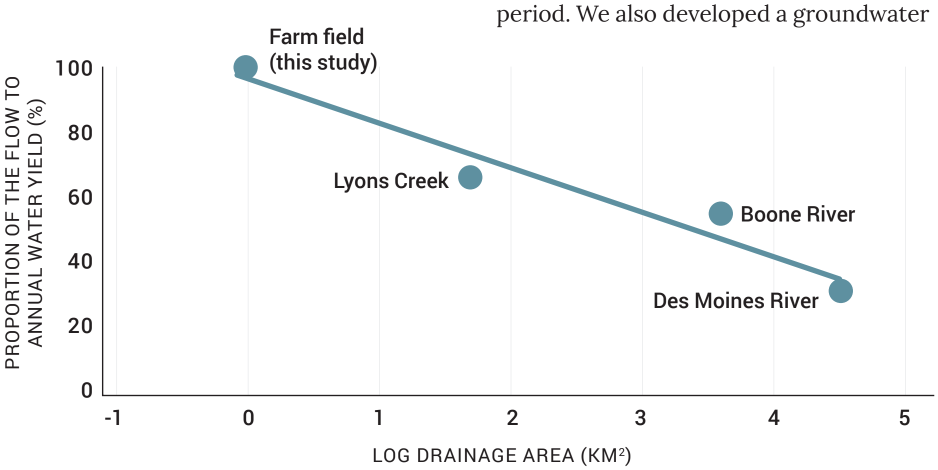
With the cooperation of the land manager, IGS staff conducted a geophysical survey and installed nine shallow groundwater monitoring wells in the 160-acre field (Fig. 1). Partnering with Anthony Seaman from the Iowa Soybean Association, we subsequently collected samples from eight tile outlets, nine groundwater wells, and the receiving stream over a two-year period. We also developed a groundwater flow model (MODFLOW) to estimate groundwater seepage to the stream. From the study, we found that within this single field, subsurface drainage tiles contributed approximately 98% of the annual nitrate load and 99.7% of the OP load to the perennial stream.

The load contributions from tiles may be surprising to some but the percentages are actually consistent with previous work in the Boone River Watershed. Schilling et al. (2019) reported that tile drainage accounted for approximately 44–66% of the annual water yields in the Boone River basin and 32% of the flow in the 16,175-km² Des Moines River basin. Overall, the proportion of river water yields derived from tiles changes with spatial scale, increasing as drainage areas get smaller within the intensely drained Des Moines Lobe region of Iowa (Fig. 2).

Our observations that tile flows were dominating nutrient loads suggested that edge-of-field practices such as bioreactors or saturated buffers are needed to reduce stream nutrients. We estimated that a load reduction of 28% could be achieved by installing bioreactors to address the two highest exporting tiles, whereas a saturated buffer installed along the northern side of the field could potentially achieve a load reduction of nearly 43%. Although these practices have not been installed to date, our research has shown that improved quantification of nutrient loading from single fields to watersheds can help site conservation practices where they will have the greatest benefit. The results of this study were published in the journal *Agricultural Water Management*.

FIGURE 1

FIGURE 2: Relation of proportion of annual water yield derived from tile discharge to drainage area within the Des Moines Lobe region of Iowa. Values for Lyons Creek, Boone River, and Des Moines River are from Schilling et al. (2019).



REFERENCE: Schilling, K.E., Gassman, P.W., Arenas-Amado, A., Jones, C.S., and Arnold, J. (2019). "Quantifying the contribution of tile drainage to basin-scale water yield using analytical and numerical models." *Science of the Total Environment*, 657, 297–309.

IGS Research Supports Flood Control Efforts in NE Iowa

By Ryan Clark

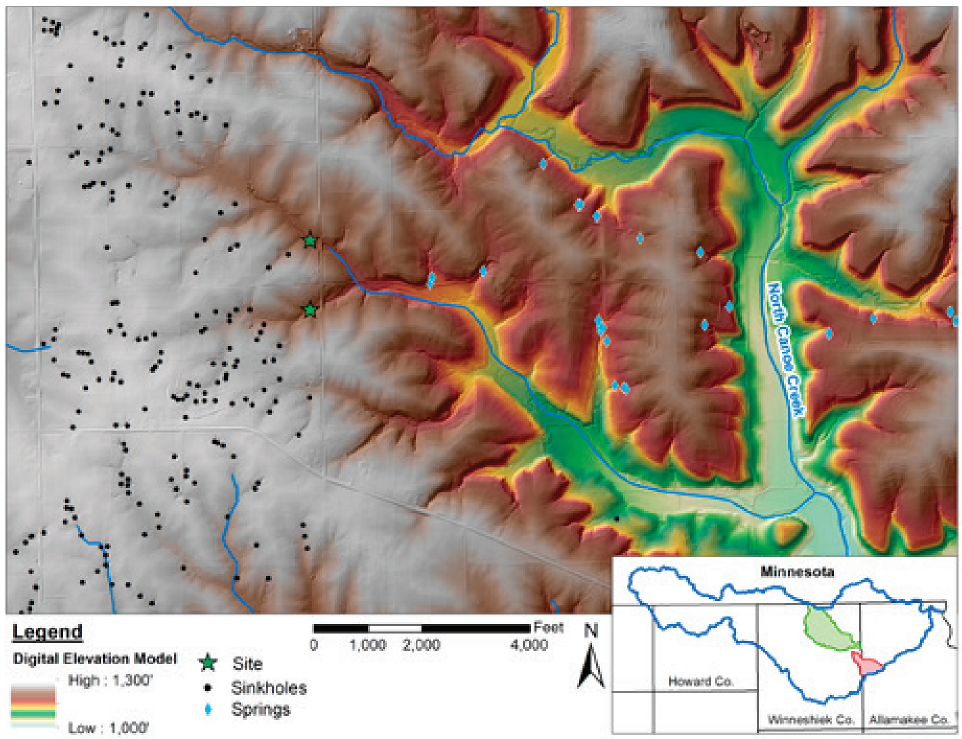
WHEN THE UPPER IOWA RIVER (UIR) Watershed Management Authority (WMA) formed in 2015, its goal was to mitigate the destructive effects of flash flooding during intense rain events. The landscape of the UIRW is unique compared to other Iowa watersheds in its extreme topography and the prevalence of karst geology.

The UIRWMA, along with engineering consultant Shive-Hattery Inc., enlisted the services of the Iowa Geological Survey (IGS) to evaluate the viability of three sites in karst-prone areas for stormwater retention structures. Two sites were in the Canoe Creek subwatershed, and the third was in the Coon Creek subwatershed. IGS staff conducted field reconnaissance, performed electrical resistivity (ER) surveys, and coordinated subsurface drilling to assess the geologic conditions at each site.

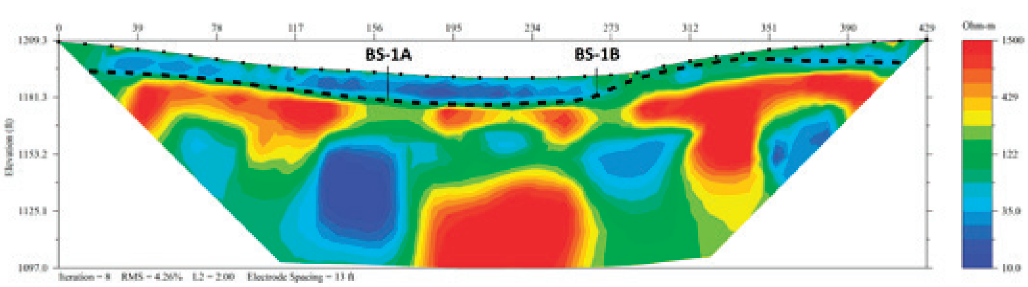
All three sites were characterized as having less than 20 feet of unconsolidated materials overlying limestone bedrock. Bedrock exposures were observed at two of the sites. Based on the ER surveys, the team identified several potential anomalies as potential karst-forming areas. The team targeted those areas for drilling and determined that they were underlain by competent bedrock.

Ultimately, all three sites were deemed viable due to the subsurface conditions observed. IGS researchers determined that water retention would be temporary, thus reducing the risk of infiltration into the karst bedrock below.

DIGITAL ELEVATION MODEL (DEM) created from LiDAR coverage of the Upper Iowa River Watershed illustrating the extreme topography in the study area. Sinkholes and springs are noted based on field verification from a previous survey of the watershed. Inset map shows the UIRW (blue), Canoe Creek (green), and Coon Creek (red) subwatershed boundaries.



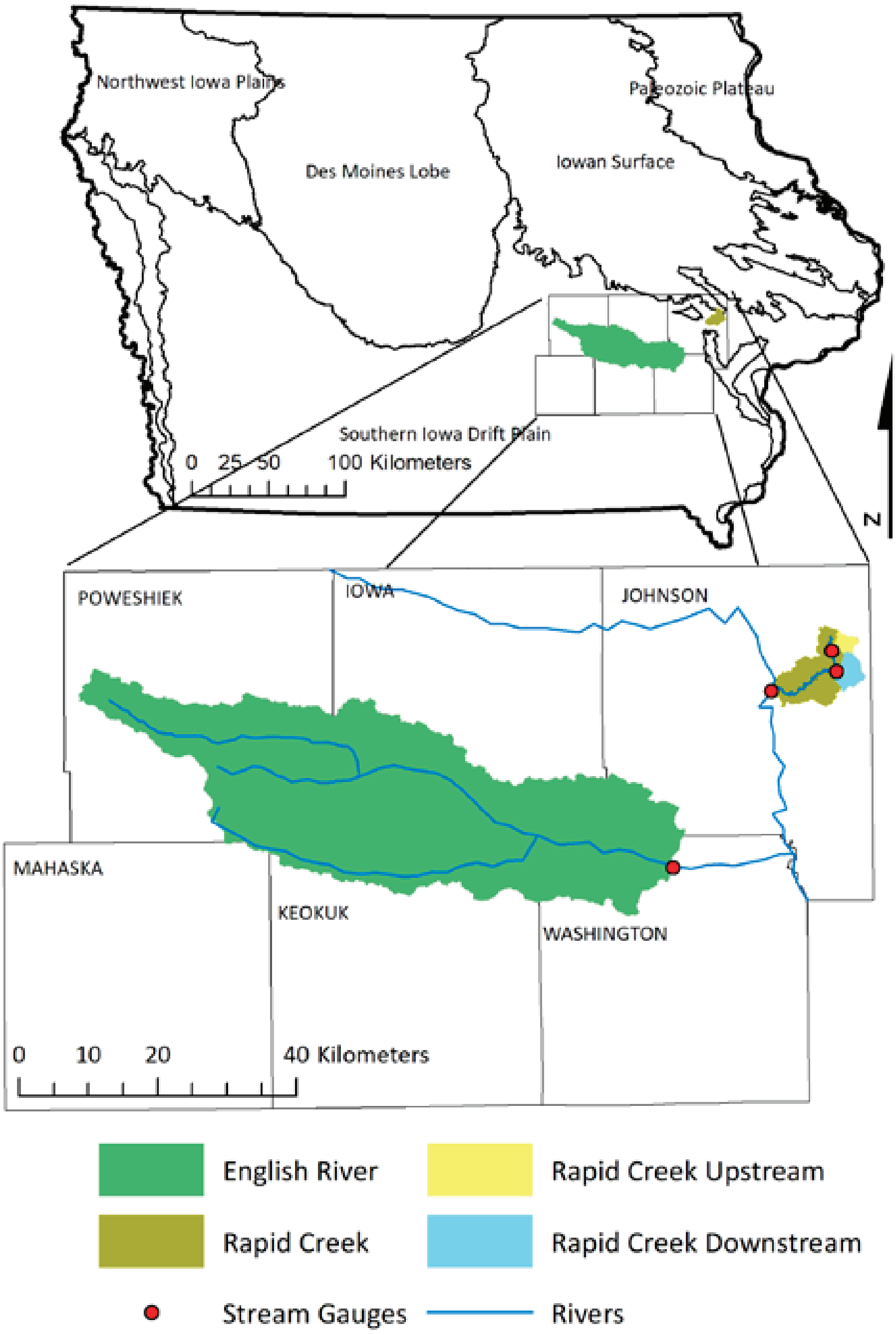
SOUTH LINE 1



RESULTS OF the electrical resistivity survey for one of the four lines deployed at the southern site in the Canoe Creek subwatershed. Black dashed line illustrates the estimated bedrock surface. Black dots on the surface are electrodes. Boreholes drilled are labeled. Warm colors are resistive (limestone bedrock, dry zones) and cool colors are conductive (clayey material, void spaces, or moisture-rich zones).

Erosion and Sediment Delivery in Southern Iowa Watersheds: Implications for Conservation Planning

by Matthew Streeter

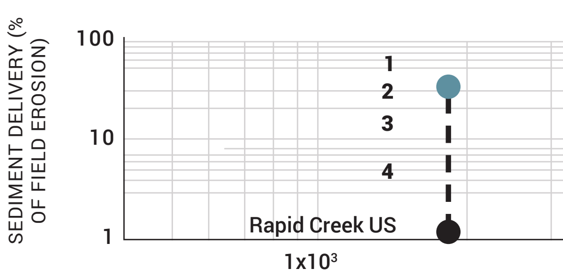


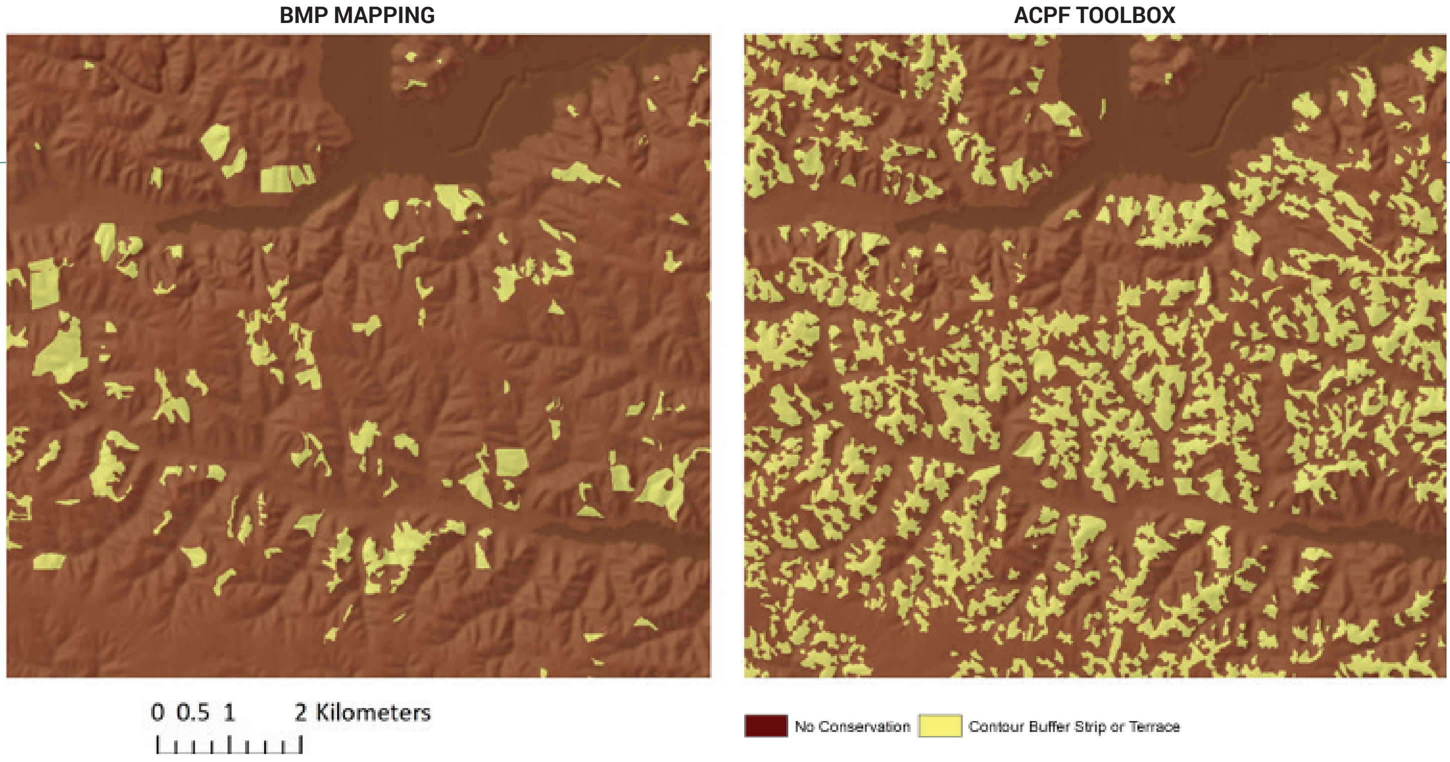
SEDIMENT ERODING FROM AGRICULTURAL croplands is a major contributor to water-quality impairment in midwestern streams. Reducing soil export from agricultural watersheds is a key component of the Iowa Nutrient Reduction Strategy.

Over the last few decades, improvements in land management and installation of best management practices (BMPs) have reduced field-scale soil erosion, but water-quality benefits of BMPs have been poorly quantified. Reducing the amount of soil erosion occurring from field to field is not the same as reducing the amount of sediment exported from a watershed, so sediment delivery ratios (SDRs) are used to estimate the fraction of gross soil erosion exported from a watershed for a given period of time.

In 2020, IGS Soil Scientist Matthew Streeter and State Geologist Keith Schilling published new research in the *Journal of Soil and Water Conservation* that studied five eastern Iowa watersheds ranging in size from 8–1,487 km^2. Their objective was to develop a new SDR curve for the Southern Iowa Drift Plain landform region in southeast Iowa that accounts for the effects of currently implemented BMPs, as well as current climatic conditions.

The watersheds of interest included the HUC 12 Rapid Creek Watershed in Johnson County and two of its headwater subbasins,





as well as the much larger English River Watershed, which stretches from its headwaters near Grinnell in Poweshiek County to its discharge to the Iowa River in Washington County (Fig. 1).

The team used several new technologies to make accurate estimates of in-field soil erosion and total suspended solid (TSS) concentrations in streams. First, they modeled watershed-scale sheet and rill soil erosion using the Revised Universal Soil Loss Equation (RUSLE). RUSLE data are widely available in Iowa. However, typically, RUSLE models use 30-year average rainfall data rather than yearly estimates and do not account for agricultural conservation practices such as reduced tillage, contour planting, or terrace construction, all of which may have significant impacts on rates of soil erosion. The IGS team gathered maps of existing structural BMPs within the watersheds (provided by the Iowa BMP mapping project). With this information, they estimated the land area within the watersheds where soil erosion is reduced and sediment trapping occurs due to BMPs. These included contour terraces, contour buffer strips, and water and sediment control basins (Fig. 2). The IGS also acquired current annual rainfall estimates for the watersheds. They ran the RUSLE models again with the additional data to generate new soil erosion estimates. The team used the Agricultural Conservation Planning Framework (ACPF) toolbox to determine the best sites for new conservation practices within each watershed (Fig. 2). Again, the RUSLE model was used to make predictions about potential future reductions in soil erosion if new BMPs are installed.

In order to estimate TSS within each study stream, researchers installed turbidity sensors to collect continuous data in the English River and Rapid Creek headwater subbasins. In addition, sensors gathered data on total phosphorus concentrations from the Rapid Creek Watershed near the stream's outlet. Turbidity and total phosphorus data were then converted to TSS using a calibration curve developed using Iowa Department of Natural Resources ambient water-quality data from the nearby Old Man's Creek Watershed.

The ratio of RUSLE-estimated soil erosion with new estimates of conservation practices and rainfall to the estimated TSS provides significant insights on the state of soil conservation in Iowa. We found that SDRs from our study were significantly lower compared to previous estimates made by the USDA in its 1998 field office technical guide *Erosion and Sediment Delivery* (Fig. 3). Furthermore, we found that the construction of thousands of additional conservation practices within the study watersheds would not significantly reduce soil erosion. However, the ability of these proposed conservation practices to trap detached soil sediments could significantly reduce overall sediment export.

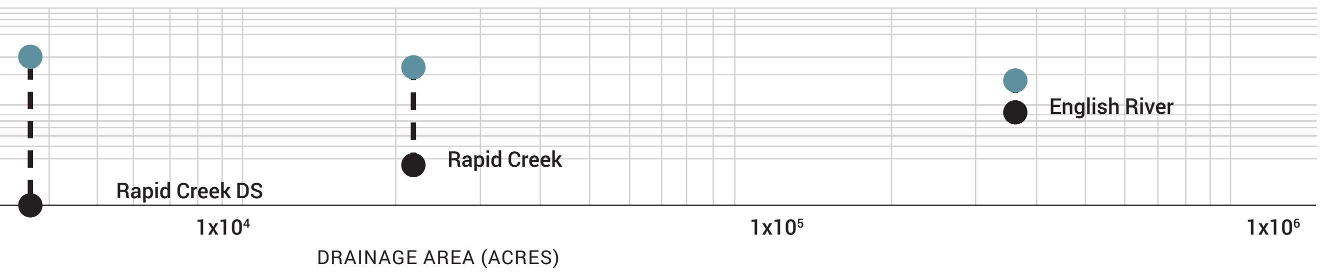


FIGURE 3: Estimated sediment delivery for landform regions.

Iowa's Beautiful and Mysterious Maquoketa Caves State Park

THE VIEW from inside Dancehall Cave.

By Rick Langel

FEELING ADVENTUROUS? A visit to Iowa's Maquoketa Caves State Park in east-central Iowa may be just the thing! Caves with intriguing names such as Fat Man's Misery and Dancehall Cave offer opportunities for amateur spelunkers to see beautiful and unique geological features.

Maquoketa Caves State Park encompasses 192 acres in Jackson County northwest of Maquoketa. A series of 13 caves, a balanced rock, and a natural bridge are among the features found in the park. Efforts to protect the caves began in the 1920s when private groups began purchasing land in the area. Iowa officially designated Maquoketa Caves as a state park in 1933.

The spectacular rocks in Maquoketa Caves State Park are Silurian age dolomites. The rocks initially formed as deposits of lime sediment on the bottom of an extensive shallow tropical sea about 430 million years ago. The lime sediments were converted to dolomite in a process called dolomitization, likely later in the Silurian as the seas withdrew across the region.

These seas were inhabited by a variety of creatures, whose remains can be found as fossils and fossil molds in the rocks. Fossil molds are the result of the original fossil material dissolving during dolomitization, which leaves an external and sometimes an internal mold. Fossils identified in the rocks include crinoids (sea lilies), corals, sponges (stromatoporoids), bryozoans, brachiopods, snails (gastropods), clams (bivalves), nautiloids, and trilobites.

The caves, sinkholes, and other features in the park are prime examples of karst topography. Karst topography forms by the dissolving action of groundwater on carbonate rock. The caves in the park can be classified as either solutional or mechanical, depending on how they formed.

Solutional caves begin with groundwater following cracks and fractures in the rock. Groundwater contains a weak, naturally occurring acid. The dolomites dissolve as groundwater moves through the cracks and fractures, which enlarge and allow more groundwater to flow, causing more dissolution. Over thousands of years, small cracks and fractures become large voids, which in turn become caves. Dancehall Cave is an example of a solution cave within the park.

Mechanical caves form when large blocks of rock collapse. Water seeping through the dolomite lubricates underlying rocks. Under the influence of gravity, blocks of dolomite can slide and rotate, creating fractures and caves. Fat Man's Misery is an example of a mechanical cave within the park.

Groundwater is also responsible for features visible in the caves. The groundwater can deposit calcium carbonate as it flows through air-filled portions of caves. Water dripping from the cave's ceiling forms hollow, cylinder-shaped soda straws or solid, cone-shaped stalactites. Water splashing on the cave's floor forms stalagmites. Water flowing on the cave's walls forms flowstone.

Many features in the park are the remnants of a larger cave system. Erosion collapsed portions of the original cave's roof. Many of the current caves are believed to have been side passages in the larger cave. The park's "Natural Bridge" formed as a result of this collapse.

A six-mile trail connects all the caves, each of which is unique. The largest, Dancehall Cave, offers a lighted walkway and can be explored day or night. Other caves require a flashlight and crawling to explore. A short program at the park teaches visitors about White Nose Syndrome (a disease that kills bats) and is required for those planning to explore the caves.

Partnering with the Iowa Department of Natural Resources

IGS WORKS COLLABORATIVELY with the Iowa Department of Natural Resources (IDNR) on many issues related to Iowa's water and natural resources. The organizations share data and expertise across several different platforms, with information related to well records, geologic samples, pump test data, and other geospatial data. During the 2019–20 fiscal year, IGS provided IDNR the following services:

- Keith Schilling assisted the DNR by leading a New Year's Day "First Day Hike" at Cedar Rock State Park.
- Updated GeoSam with records from over 2,600 wells. Twenty-two of the records were specifically for the DNR's Water Use and Public Water Supply program well. Eighty-four were specifically for the DNR's Animal Feeding Operation program.
- Provided lithologic strip logs for one well and part of another, totaling 1,385 feet.
- Analyzed and entered 23 pump tests to IGS PumpTest database for DNR to access.
- Evaluated shallow groundwater levels on a monthly basis for inclusion in the DNR's Drought Summary update.
- Provided technical assistance on a geophysical investigation of the Amana wellfield to the DNR's Water Supply group.
- Updated the statewide Cambrian-Ordovician groundwater flow model to local conditions found in the Des Moines Metropolitan Area.

STATE GEOLOGIST Keith Schilling (below, center) assisted the DNR by leading a New Year's Day "First Day Hike" at Cedar Rock State Park.

Publications by the IGS Staff in 2019–20

Bressen, F., R. Mantilla, **K.E. Schilling**, J.A. Palmer, and L. Weber, 2019. "Hydrologic-hydraulic modeling of sediment transport along the main stem of a watershed: Role of tributaries and channel geometry," *Hydrological Sciences Journal*, doi: 10.1080/02626667.2019.1687897.

Clark, R.J. and **P. Kerr**, 2020. Bedrock Elevation and Quaternary Thickness Map of the Donnellson 7.5' Quadrangle, Lee County, Iowa: Iowa Geological Survey, Open File Map OFM-20-3, 1:24,000 scale map sheet.

Clark, RJ.. and **P. Kerr,** 2020. Bedrock Elevation and Quaternary Thickness Map of the West Point 7.5' Quadrangle, Lee County, Iowa: Iowa Geological Survey, Open File Map OFM-20-6, 1:24,000 scale map sheet.

Clark, R.J., **S. Tassier-Surine**, and **P. Kerr**, 2020. Bedrock Geologic Map of the Donnellson 7.5' Quadrangle, Lee County, Iowa: Iowa Geological Survey, Open File Map OFM-20-1, 1:24,000 scale map sheet.

Clark, R.J., **S. Tassier-Surine**, and **P. Kerr,** 2020. Bedrock Geologic Map of the West Point 7.5' Quadrangle, Lee County, Iowa: Iowa Geological Survey, Open File Map OFM-20-4, 1:24,000 scale map sheet.

Cramer, B.D., B.M. Stolfus, J.E. Day, **R.J. Clark**, N.J. Hogancamp, B.J. Witzke, and **S. Tassier-Surine,** 2019. "The Devonian-Carboniferous Boundary in the Mississippi River Valley of Iowa, Illinois, and Missouri," in Cramer, B.D. (ed.), *The Devonian-Carboniferous Boundary in the Type Area of the Mississippian,* Iowa Geological Survey Guidebook Series, v. 30, p. 1–9.

Drenth, B.J., A.K. Souders, K.J. Schulz, J.M. Feinberg, R.R. Anderson, V.W. Chandler, W.F. Cannon, and **R.J. Clark**, 2020. "Evidence for a Concealed Midcontinent Rift-Related Northeast Iowa Intrusive Complex," *Precambrian Research,* v. 347, https://doi.org/10.1016/j.precamres.2020.105845.

Gu, X., H. Sun, G.R. Tick, Y. Lu, Y.K. Zhang, Y. Zhang, and **K.E. Schilling**, 2020. "Identification and scaling behavior assessment of the dominant hydrological factors of nitrate concentrations in streamflow," *Journal of Hydraulic Engineering*, 25(6), 06 06020002.

Jones, C.S. and **K.E. Schilling**, 2019. "Iowa statewide stream nitrate loading: 2017–18 update," *Journal of the Iowa Academy of Science*, 126:6-12.

Kerr, P., **S. Tassier-Surine, R. Langel**, and **R.J. Clark**, 2020. Surficial Geologic Map of the Van Horne Quadrangle, Benton County, Iowa: Iowa Geological Survey, Open File Map OFM-20-7, 1:24,000 scale map sheet.

Kerr, P., **S. Tassier-Surine**, **R. Langel**, and **R.J. Clark**, 2020. Surficial Geologic Map of the Keystone South Quadrangle, Benton County, Iowa: Iowa Geological Survey, Open File Map OFM-20-9, 1:24,000 scale map sheet.

Langel, R. and **P. Kerr**, 2020. Bedrock Elevation and Quaternary Thickness Map of the Van Horne 7.5' Quadrangle, Benton County, Iowa: Iowa Geological Survey, Open File Map OFM-20-8, 1:24,000 scale map sheet.

Langel, R. and **P. Kerr**, 2020. Bedrock Elevation and Quaternary Thickness Map of the Keystone South 7.5' Quadrangle, Benton County, Iowa: Iowa Geological Survey, Open File Map OFM-20-10, 1:24,000 scale map sheet.

Meulemans, M.J., C.S. Jones, **K.E. Schilling**, N.C. Young, and L.J. Weber, 2020. "Assessment of spatial nitrate patterns in an eastern Iowa watershed using boat-deployed sensors," *Water*, 12, 146.

Prokopy, L.S., B.M Gramig, A. Bower, S.P. Church, B. Ellison, P.W. Gassman, K. Genskow, D. Gucker, S.G. Hallet, J. Hill, N. Hunt, K.A. Johnson, I. Kaplan, J.P. Kelleher, H. Kok, M. Komp, P. Lammers, S. LaRose, M. Liebman, A. Margenot, D. Mulla, M.J. O'Donnell, A.W. Pelmer, E. Reaves, K. Salazar, C. Schelly, **K.E. Schilling**, S. Secchi, A.D. Spaulding, D. Swenson, A.W. Thompson, and J.D. Ulrich-Schad, 2020. "The urgency of transforming the midwestern U.W. landscape into more than corn and soybean," *Agriculture and Human Values*, doi: 10.1007/s10460-020-10077-x.

Schilling, K.E., K. Wilke, C.L. Pierce, K. Kult, and A. Kenny, 2019. "Multipurpose oxbows as a nitrate export reduction practice in the agricultural Midwest," *Agricultural & Environmental Letters*, 4:190035.

Schilling, K.E., **M.T Streeter**, A. Seeman, and C.S. Jones, 2020. "Total phosphorus export from Iowa agricultural watersheds: Quantifying the scope and scale of a regional condition," *Journal of Hydrology*, 581:124397.

Schilling, K.E., **M.T. Streeter**, **J. Vogelgesang**, C.S. Jones, and A. Seeman, 2020. "Subsurface nutrient export from a cropped field to an agricultural stream: Implications for targeting edge-of-field practices," *Agricultural Water Management*, 241:106339.

Schilling, K.E., P.J. Jacobson, M. St. Clair, and C.S. Jones, 2020. "Dissolved phosphate concentrations in Iowa shallow groundwater," *Journal of Environmental Quality*, doi.org/10.1002/jeq2.20073.

Streeter, M.T., **K.E. Schilling**, and C. Wolter, 2020. "Erosion and sediment delivery in southern Iowa watersheds: Implications for conservation planning," *Journal of Soil and Water Conservation*, In press.

Streeter, M.T., **K.E. Schilling**, and Z. Demanett, 2019. "Soil health variations across an agricultural-urban gradient, Iowa, USA," *Environmental Earth Sciences*, 78(24), 691.

Selected Presentations by IGS Staff 2019–20

Tassier-Surine S., R.J. Clark, and **P. Kerr**, 2020. Surficial Geologic Map of the West Point 7.5' Quadrangle, Lee County, Iowa: Iowa Geological Survey, Open File Map OFM-20-5, 1:24,000 scale map sheet.

Tassier-Surine, S., **R.J. Clark**, and **P. Kerr**, 2020. Surficial Geologic Map of the Donnellson 7.5' Quadrangle, Lee County, Iowa: Iowa Geological Survey, Open File Map OFM-20-2, 1:24,000 scale map sheet.

Thomas, W.A., G.E. Gehrels, K.E. Sundell, S.F. Greb, E.S. Finzel, **R.J. Clark**, D.H. Malone, B.A. Hampton, and M.C. Romero, 2020. "Detrital Zircons and Sediment Dispersal in the Eastern Midcontinent of North America," *Geosphere*, v. 16, https://doi.org/10.1130/GES02152.1.

Thompson, D.A., H.-J. Lehmler, D. Kolpin, M.L. Hladik, J. Vargo, **K.E. Schilling**, G.H. LeFevre, T. Peeples, M.C. Poch, L.E. LaDuca, D.M. Cwiertny, and R.W. Field, 2020. "A critical review on the potential impacts of neonicotinoid insecticide use: Current knowledge of environmental fate, toxicity, and implications for human health," *Environmental Science: Processes and Impacts*, doi: 10.1039/C9EM00586B.

Vogelgesang, J.A., 2019. "Hydrogeophysical activities of the Iowa Geological Survey," *Environmental and Engineering Geophysical Society*, FastTIMES 24:5.

Vogelgesang, J.A., **N. Holt**, **K.E. Schilling**, **M. Gannon**, and **S. Tassier-Surine**, 2020. "Using high-resolution electrical resistivity to estimate hydraulic conductivity and improve characterization of alluvial aquifers," *Journal of Hydrology*, 580:123992.

Clark, R.J. "Using Geophysics to Assess Groundwater Resources," Iowa Water Well Association Annual Conference and Trade Show, Jan. 30, 2020.

Gannon, J.M., "Future Water Allocations and Water Storage in the Jordan Aquifer in Iowa – Pattison Mine Example," Iowa Sierra Club, Oct. 22, 2020.

Gannon, J.M., "Source Water Assessment Lyon-Sioux Rural Water-Doon Wellfield," Rock Rapids, Iowa, Community Center, Jan. 14, 2020.

IGS Staff, outreach event open to the public, Bettendorf, Iowa, Public Library, Nov. 22, 2019.

IGS Staff, outreach event open to the public, Independence, Iowa, Public Library, Nov. 19, 2019.

Langel, R.J., "Groundwater on the Move," 2019 STEM Institute for Young Scientists, Nov. 26, 2019.

Langel, R.J., "Iowa Well Forecasting System," Iowa Flood Center seminar, August 21, 2019.

Langel, R.J., "The Iowa Geological Survey's Rock Library," AASG Drill Core Repository Webinar, April 23, 2020.

Langel, R.J., "The Iowa Well Forecasting System (IWFoS): A Web Application to Predict Aquifers and Groundwater Quality," Iowa Groundwater Association Fall Meeting, Oct. 27, 2019.

Schilling, K.E., "Changes in Hydrology Drive Consequences and Solutions in Midwestern Agricultural Watersheds," ISAP Risk Management Webinar: Climate Risk and Adaptations, June 21, 2020.

Schilling, K.E., "Contribution of Streambank Erosion to Total Phosphorus Loads in Iowa Agricultural Watersheds," Soil and Water Conservation Society Annual Meeting, July 28, 2020.

Schilling, K.E., "Multi-Purpose Oxbows as a Nitrate Export Reduction Practice in the Agricultural Midwest," Partners for Scott County Watersheds Forum, April 21, 2020.

Schilling, K.E., "Quantifying the Magnitude and Extent of Streambank Erosion in Iowa: Have We Shifted Sediment Sources from the Field to the Stream?" Earth and Environmental Sciences (EES) Seminar, University of Iowa, Jan. 31, 2020.

Schilling, K.E., "Using Landscape Opportunities to Increase Resilience Against Climate Extremes and Flooding," Flooding and Climate Symposium, Soil and Water Conservation Society Annual Meeting, July 28, 2020.

Schilling, K.E., "Water Table Fluctuations in Tiled Glacial Landscapes," Soil Health and Watershed Health Workshop, University of West Virginia, Feb. 12, 2020.

Streeter, M.T., "Erosion and Sediment Delivery in Iowa," University of Iowa EES Seminar, Mar. 6, 2020.

Tassier-Surine, S., "Geologic Mapping: Understanding Past Environments and Informing Future Decisions," University of Iowa EES Seminar, Oct. 14, 2019.

Vogelgesang, J.A., "Electrical Resistivity Data Collection: An Overview of Field Methodology," Iowa Department of Transportation field demonstration, Sept. 10, 2019.

Vogelgesang, J.A. and R.J. Langel, "Data at Your Fingertips: An Overview of the IGS Web Applications," National Geological and Geophysical Data Preservation Program Workshop, Sept. 24, 2019.

Selected FY20 IGS Projects

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 and Mike Gannon: Iowa Department of Natural Resources (IDNR)

Connecting the Iowa Geological Survey's Iowa Water-Level Network Wells with the National Ground-Water Monitoring Network: Richard Langel: U.S. Geological Survey (USGS)

Developing Areas and Impaired Watershed Mapping in Southeast Iowa: Bedrock and Surficial Geologic Maps of the Donnellson and West Point Quadrangles: Stephanie Tassier-Surine: USGS

Development of a Groundwater Modeling Tool for the Jordan Aquifer in the Des Moines Metropolitan Area with Site-Specific Model Application to the City of Altoona: Mike Gannon: Altoona, Iowa (City of)

Development of a Groundwater Modeling Tool for the Jordan Aquifer in the Des Moines Metropolitan Area with Site-Specific Model Application to the City of West Des Moines: Mike Gannon: West Des Moines Water Works

Development of a Groundwater Modeling Tool for the Jordan Aquifer in the Des Moines Metropolitan Area with Site-Specific Model Application to Des Moines Water Works: Mike Gannon: Des Moines Water Works

Development of a Local-Scale, Site-Specific Groundwater Modeling Tool for the Management and Optimization of Koch Nitrogen's Water Supply: Mike Gannon: Koch Fertilizer LLC

EM Geophysical Survey at the 200 Block of East Second Street, Davenport, Iowa: Jason Vogelgesang: Impact7G66

Earth MRI – Devonian Phosphates: Ryan Clark: USGS

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

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: Iowa Nutrient Research Center (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, Drilling, and Evaluation Services near Durango, Iowa: Jason Vogelgesang: IDOT

Geophysical, Drilling, and Evaluation Services near Mason City, Iowa: Jason Vogelgesang: IDOT

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

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

Hydraulic Testing of Mississippian and Devonian NGWMN Wells by the Iowa Geological Survey: Richard Langel: USGS

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

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

Model the Cambrian-Ordovician Aquifer in NW Illinois: Richard Langel: Illinois Department of Natural Resources

Development of a Local-Scale Groundwater Modeling Tool for the Management and Optimization of the Tyson Meats (Perry Plant) Jordan Wellfield: Mike Gannon: Tyson Foods

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

Quantifying the Effects of BMPs on Sediment and Phosphorus Delivery to a Range of Eastern Iowa Rivers: Keith Schilling: INRC

Scanning Geophysical Logs: Richard Langel: Northern Natural Gas (NNG)

Seismic Monitoring Services at the NNG Redfield Facility: Jason Vogelgesang: NNG

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

Financials

Source Water Assessment at Lyon-Sioux Rural Water System Doon Wellfield: Mike Gannon: Lyon and Sioux Rural Water System Inc.

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

Total Phosphorus Loads in Iowa Rivers and Estimation of Steam Bank Phosphorus Contribution: Keith Schilling: INRC *PHOScont

Total Phosphorus Turbidity Evaluation 2019: Keith Schilling: IDNR

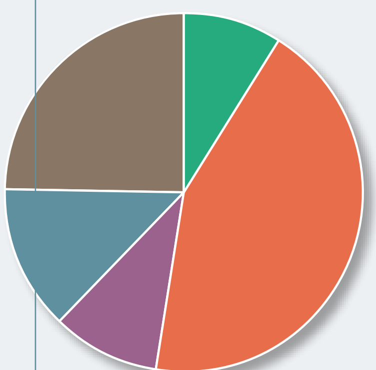
Upper Iowa River Watershed Flood Mitigation Site Characterization Study: Ryan Clark: U.S. Department of Housing and Urban Planning, Shive-Hattery Engineers and Architects Inc.

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

West Metro ASR Evaluation: Mike Gannon: West Des Moines (City of)

THE IOWA GEOLOGICAL SURVEY (IGS) is funded through a combination of sources. A state appropriation provides about 40% 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 2019–20, these funding sources included local municipalities, state agencies, U.S. Geological Survey, and Iowa Nutrient Research Center, among others. It is noteworthy that the entire 2019–20 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 to ensure sustainable water resources for Iowans and provide science-based information to support well drillers, government officials, and individuals. As always, the IGS remains willing to collaborate with new and existing clients on exciting, impactful projects.

FY 2020 $1,596,525



Municipal: City water supply projects (9%)

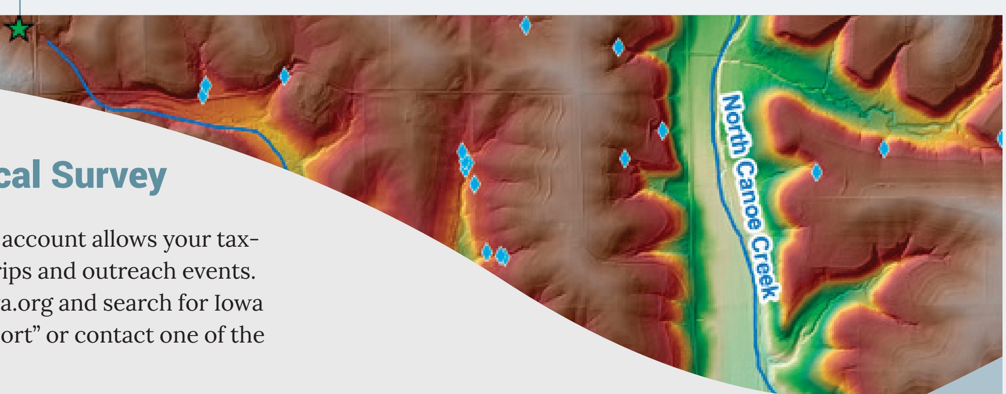
State Appropriation: Funded through DNR prior to FY2019 (43%)

INRC: Iowa Nutrient Research Center (10%)

Federal Agency: United States Geological Survey, Natural Resources Conservation Service (13%)

Other: Non-government contracts, State Agency, Iowa DOT, Iowa Dept. of Agriculture and Land Stewardship (25%)

FY 2016	FY2017	FY2018	FY2019	FY2020
$1,340,314	$1,394,092	$1,450,727	$1,633,533	$1,596,525



Give to the Iowa Geological Survey

The Iowa Geological Survey foundation account allows your tax-deductible gift to support future field trips and outreach events. Give online at https://donate.givetoiowa.org and search for Iowa Geological Survey under "Areas to Support" or contact one of the individuals listed below:

To make your tax-deductible gift, contact:

Matt Kuster Matt.Kuster@foriowa.org, 319-467-3720)

State Geologist Keith Schilling (keith-schilling@uiowa.edu, 319-335-1422)

Carmen Langel (carmen-langel@uiowa.edu, 319-335-5841)

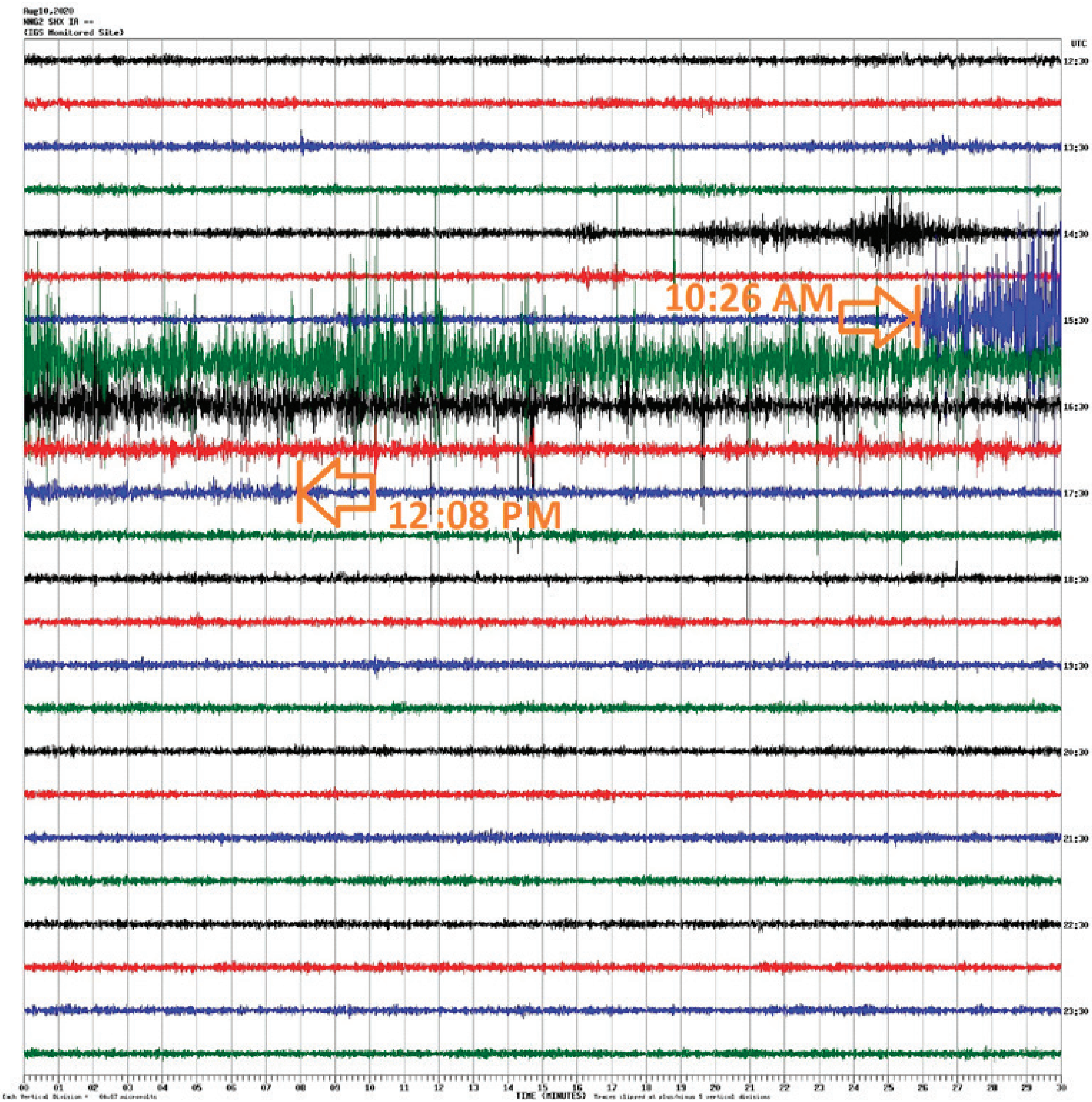
Please add "IGS" to the memo line of your check.

Thank you!

IOWA GEOLOGICAL SURVEY

A Historic Windstorm

This amazing image shows how the Iowa Geological Survey's real-time geophysical sensors in the Des Moines area captured Iowa's historic derecho storm. The IGS's Jason Vogelgesang says, "You can see the waveform responding to the immense wind, beginning at 10:26 am and fading back to normal background conditions at 12:08 pm."



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