Champaign County
Department of

PLANNING &
ZONING

**Bennett Administrative Center**
102 E. Main Street
Urbana, Illinois 61801

(217) 384-3708
zoningdept@champaigncountyil.gov
www.co.champaign.il.us/zoning

# *CASE 212-AT-26*

*PRELIMINARY MEMORANDUM*
*July 9, 2026*

**Petitioner:** Zoning Administrator

**Request:** Amend the Champaign County Zoning Ordinance by deleting Section 5.5 Safety Moratorium on Carbon Sequestration Activity and adding “Carbon Dioxide Sequestration Facility” to be allowed by a County Board Special Use Permit in the AG-1 Agriculture, AG-2 Agriculture, and I-2 Heavy Industry Zoning Districts and adding requirements for Carbon Dioxide Sequestration Facility as summarized in the attached legal advertisement.

**Location**: Unincorporated Champaign County

**Time Schedule for Development:** As soon as possible

**Prepared by**: **John Hall**
Zoning Administrator

**Charlie Campo**
Senior Planner

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## BACKGROUND

The Inflation Reduction Act (2022) increased tax credit incentives for carbon sequestration to $85 per ton and greatly increased the interest in carbon capture and sequestration.

Illinois’ Safety and Aid for the Environment in Carbon Capture and Sequestration Act (SAFE CCS Act) became effective on January 1, 2025. The SAFE CCS Act supplemented federal regulation of carbon dioxide injection and added a State permit requirement for injection of carbon dioxide.

Due to concerns about the risks that carbon sequestration posed to the Mahomet Aquifer, the County Board adopted a temporary moratorium on carbon sequestration activity in Zoning Case 157-AT-24 on January 23, 2025, and on March 20, 2025, appointed a Carbon Sequestration Activities Task Force to develop a comprehensive Zoning Ordinance text amendment to regulate carbon sequestration activities. The ZBA held a public hearing for the moratorium on December 12, 2024, and viewed a presentation by the Illinois State Geological Survey on Groundwater Protection and Carbon Storage (see attached). The temporary moratorium was extended for six months on December 18, 2025, and again on May 21, 2026.

At the April 21, 2025 meeting of the Carbon Sequestration Activities Task Force, Dr. Don Wuebbles, emeritus professor in the atmospheric sciences department at the University of Illinois at Urbana-Champaign and who served as the President’s expert on climate science during the Obama administration, explained that the climate is changing and it is changing more rapidly than nature would tend to shift climate, and it is due to human activities and associated pollution. Dr. Wuebbles also explained that various analyses show that the cost of inaction is greater than the cost of taking action and that to achieve the necessary reductions in temperature increase and pollution emissions, we must significantly reduce the amount of carbon dioxide released into the atmosphere.

At the same meeting, Randy Locke with the Illinois State Geological Survey of the Prairie Research Institute explained that the U.S. Department of Energy created a carbon management strategy in the 1990's that developed regional deployment of assessment of carbon storage options throughout different parts of the U.S. Mr. Locke explained that the Illinois Basin (see Attachment C) has been identified as able to store decades to centuries of carbon emissions within the area of the Illinois Basin and that is why the Illinois Basin is seen as a significant resource.

Public Act 104-0119 (SB1723) became law on August 1, 2025, and prohibits carbon sequestration activity within a sequestration facility that overlies, underlies, or passes through a sole source aquifer (the Mahomet Aquifer). Not all of Champaign County lies over the Mahomet Aquifer and so some parts of Champaign County may be proposed for carbon sequestration.

The County Board also provided partial funding for a study of the extent of the Mahomet Aquifer using helicopter-borne time-domain electromagnetic measurement (HTEM) and received the results of that study on February 27, 2026. The HTEM study greatly expanded the known extent of the Mahomet Aquifer. A copy of the HTEM study is attached (see Attachment D).

The Carbon Sequestration Activities Task Force held its final meeting on June 3, 2026, and recommended a Draft text amendment to the Environment and Land Use Committee (ELUC). At their meeting on June 4, 2026, ELUC authorized the Draft text amendment for public hearing. The Draft text amendment is included as Attachment E.

**NEED TO ACT**

The current moratorium on carbon dioxide sequestration in the County expires on November 21, 2026. This text amendment needs to be referred to the Environment and Land Use Committee no later than September 17, 2026, in order for ELUC to have time to make a recommendation to the County Board for their consideration on November 19, 2026.

**ATTACHMENTS**

A Legal Advertisement
B *Groundwater Protection and Carbon Storage*, a PowerPoint briefing by Randy Locke, P.G., Illinois State Geological Survey
C Figures 14 and 15 from *Carbon Capture, Utilization, and Storage in Illinois*. 2022. Champaign, IL: Prairie Research Institute
D *Geophysical Mapping of the Mahomet Aquifer using Airborne Electromagnetic Method.* Kisa Mwakanyamale Gilkie, Donald A. Keefer, Jason F. Thomason, Steven Young, and Andrew J, Stumpf. Prairie Research Institute. 2026
E Carbon Sequestration Activities Task Force Recommendation (Draft text amendment) June 3, 2026

**Attachment A. Legal Advertisement**

**LEGAL PUBLICATION: WEDNESDAY, JULY 1, 2026** **CASE: 212-AT-26**

**NOTICE OF PUBLIC HEARING IN REGARD TO AN AMENDMENT TO THE TEXT OF THE CHAMPAIGN COUNTY ZONING ORDINANCE**

CASE 212-AT-26

The Champaign County Zoning Administrator, 102 E. Main Street, Urbana, has filed a petition to amend the text of the Champaign County Zoning Ordinance. The petition is on file in the office of the Champaign County Department of Planning and Zoning, 102 E. Main Street, Urbana, IL.

A public hearing will be held **Thursday, July 16, 2026, at 6:30 p.m.** prevailing time in the Shields-Carter Meeting Room, Bennett Administrative Center, 102 East Main Street, Urbana, at which time and place the Champaign County Zoning Board of Appeals will consider a petition for the following:

Amend the Champaign County Zoning Ordinance as follows regarding Carbon Sequestration activities:

1. Add relevant definitions to Section 3.0 Definitions including but not limited to, Area of Review, Cap Rock, Carbon Dioxide Plume, Carbon Dioxide Sequestration Facility, Carbon Dioxide Sequestration Field, Class VI Underground Injection Well Permit, Mahomet Aquifer, and Major Sand and Gravel Aquifer.

2. Delete Section 5.5 Safety Moratorium on Carbon Sequestration Activity.

3. Amend Section 5.2 by adding "Carbon Dioxide Sequestration Facility" to be allowed by a County Board Special Use Permit in the AG-1 Agriculture, AG-2 Agriculture, and I-2 Heavy Industry Zoning Districts.

4. Add new Section 4.2.1 C.10. to provide that a Carbon Dioxide Sequestration Facility may be authorized as a SPECIAL USE Permit in the AG-1 and AG-2 Agriculture Districts as a second PRINCIPAL USE on a LOT with another PRINCIPAL USE.

5. Add new Section 4.3.4H.4.j. to provide that a Carbon Dioxide Sequestration Facility is exempt from the Pipeline Impact Radius.

6. Add footnote 16 under the Special Provisions for the AG-1 and AG-2 Districts in Section 5.3 providing that lots in a Carbon Dioxide Sequestration Facility County Board Special Use Permit and intended for a Carbon Dioxide Sequestration Facility and related maintenance and management facilities are exempt from the requirements of Section 5.3 except as such regulations are required by Subsection 6.1.7.

7. Add new Section 5.4.3 H. that prohibits the Rural Residential Overlay Zoning District from being established within one-half mile of a Carbon Dioxide Sequestration Well in a Carbon Dioxide Sequestration Facility Special Use Permit.

8. Add new Section 6.1.7 Carbon Dioxide Sequestration Facility County Board Special Use Permit to establish requirements including but not limited to the following:

**Attachment A. Legal Advertisement**

a. No Carbon Dioxide Sequestration Facility shall be allowed over, penetrate through, or store carbon dioxide under the Mahomet Aquifer as mapped by the Prairie Research Institute.

b. No Carbon Dioxide Sequestration Facility (CDSF) shall be allowed over, penetrate through, or store carbon dioxide under a major sand and gravel aquifer. There must be geologic investigations to determine if there is a major sand and gravel aquifer where the CDSF is proposed.

c. No Carbon Dioxide Sequestration Facility (CDSF) shall be allowed to store carbon dioxide under an incorporated municipality nor shall a CDSF be allowed less than one-and-one-half miles from an incorporated municipality.

d. No Carbon Dioxide Sequestration Facility (CDSF) shall be allowed in an area where geologic strata has hazards including but not limited to faults and folds that could be fractured by carbon dioxide injection. The Zoning Administrator may require qualified third-party professionals to analyze and identify such risks at the expense of the applicant.

e. Any Special Use Permit application for a proposed Carbon Dioxide Sequestration Facility (CDSF) that has a Carbon Dioxide Plume that extends under another county shall include documentation that the other county has waived its authority to regulate the proposed CDSF in Champaign County.

f. No Carbon Dioxide Sequestration Facility shall be closer than ½ mile to a primary structure (a dwelling or business) or less than 2,000 feet from a public street.

g. A carbon dioxide injection well shall be at least 2,640 feet from the nearest principal structure and at least 2,000 feet from a public street or third-party power transmission line or communication tower and at least 5,000 feet from the end of any private air strip or airport runway.

h. Carbon Dioxide Sequestration Facility equipment shall be no less than 250 feet from a property line of a property more than 10 acres in area.

i. No part of a Carbon Dioxide Sequestration Field shall encroach beneath the property of any non-participating landowner, subject to any state statute that provides for the condemnation of land for purposes of a Carbon Dioxide Sequestration Field.

j. Any special use permit for a Carbon Dioxide Sequestration Facility that is outside of the Mahomet Aquifer and outside of any Major Sand And Gravel Aquifer shall be required to submit the following:

    (1) A project summary that includes a general description of the proposed project and plans for all proposed construction and the proposed underground storage of carbon dioxide including the Area of Review.

    (2) A Draft application for a Class VI well from the U.S. EPA and an application for carbon dioxide sequestration from the Illinois EPA.

(3) The results of geologic investigations to determine if a major sand and gravel aquifer is present at that location.

(4) The results of computational fluid dynamics modeling demonstrating the impact area and releases from a potential injection well blowout. The resulting impact area shall be reviewed and certified by qualified third-party professionals at the expense of the applicant.

(5) The applicant shall commit to providing equipment, training, and personnel to local jurisdictions to safely evacuate occupants of principal structures and outdoor gathering spaces that would be exposed to dangerous concentrations of carbon dioxide within 15 minutes and to limit exposure of principal structures and outdoor gathering spaces and livestock operations to dangerous concentrations of carbon dioxide.

(6) Consultations with the Endangered Species Program and the State Historic Preservation Officer of the Illinois Department of Natural Resources.

(7) Proposed mitigations for damage to farmland.

(8) Road use agreements with relevant highway jurisdictions.

(9) A noise study that documents compliance with the noise limits established by the Illinois Pollution Control Board.

(10) An Emergency and Remedial Response Plan.

(11) A Water Replacement Plan for any groundwater resources impacted by carbon dioxide injection.

(12) Liability insurance of $50 million in the aggregate.

(13) A requirement for the underground containment of carbon dioxide including the submission of annual reports.

(14) A requirement for notification of Champaign County whenever an injection well experiences subsurface leaks or malfunctions.

(15) Submission of semi-annual reports to the Zoning Administrator documenting the actual horizontal spread and rise of underground carbon dioxide until such time as the U.S. EPA determines that post-closure care of the project is complete or as otherwise determined by the Illinois EPA. When such reports show that the Carbon Dioxide Plume is within 90% of that which was approved, the injection of carbon dioxide shall cease and may only resume if it can be demonstrated that further injection will not risk trespass or pose a hazard to any major sand and gravel aquifer subject to review by qualified third-party professionals at the expense of the applicant. In the event that carbon dioxide has migrated beyond the approved underground plume the operator shall cease all injection of carbon dioxide and compensate the affected non-consenting landowners per the requirements of the SAFE CCS Act. In the event that the plume is moving

vertically toward the cap rock at a rate faster than anticipated the owner shall pay an approved and qualified third-party professional to perform studies to document the pace of rise and if conditions warrant the County Executive shall contact the U.S. EPA and request a halt to carbon dioxide injection.

(16) Submission of annual water quality reports highlighting any changes in groundwater chemistry and a written narrative explaining whether or not carbon dioxide has leaked from the Carbon Dioxide Sequestration Facility (CDSF) and migrated into groundwater that is a source of drinking water. Any groundwater that is contaminated by a carbon dioxide leak shall be replaced with an alternative water supply as provided for in the Water Replacement Plan.

(17) A Decommissioning and Site Reclamation Plan.

(18) A complaint hotline and report of complaints on a monthly basis.

9. Add new Section 6.1.7E.(3)a. requiring that any approved Carbon Dioxide Sequestration Facility County Board Special Use Permit shall be required to have a U.S. EPA Class VI Well Permit and a sequestration permit from the Illinois EPA prior to application for a Zoning Use Permit.

10. Add new Section 9.3.1L. requiring that a zoning use permit application fee to construct an approved Carbon Dioxide Sequestration Facility (CDSF) shall be $275 per ground surface acre of the underground carbon dioxide plume.

11. Add new Section 9.3.3B.(10) requiring that a special use permit application fee for a Carbon Dioxide Sequestration Facility (CDSF) special use permit shall be $250,000 to cover the County's cost for the review. If the County's actual costs exceed $250,000 the applicant shall be responsible for those additional costs. Any fees not spent by the County will be refunded to the applicant.

All persons interested are invited to attend said hearing and be heard. The hearing may be continued and reconvened at a later time. Meeting materials can be found online about one week before the meeting at: http://www.co.champaign.il.us/CountyBoard/meetings_ZBA.php. If you would like to submit comments or questions before the meeting, please call the P&Z Department at 217-384-3708 or email zoningdept@ champaigncountyil.gov no later than 4:30 pm the day of the meeting.

Cynthia Cunningham, Chair
Champaign County Zoning Board of Appeals

**TO BE PUBLISHED: WEDNESDAY, JULY 1, 2026 ONLY**

# GROUNDWATER PROTECTION AND CARBON STORAGE

Presented by

**Randy Locke, P.G.**

Chief Scientist, Research and Development
Illinois State Geological Survey

Briefing for Champaign County
Zoning Board of Appeals
December 12, 2024 (157AT-24)

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN




# ILLINOIS STATE GEOLOGICAL SURVEY

isgs.illinois.edu

## A resource for all stakeholders

- Repository for geologic and natural resource data
- Accurate, objective earth science research and information

## We support Illinois

- Protection of environmental quality
- Economic development
- Public safety

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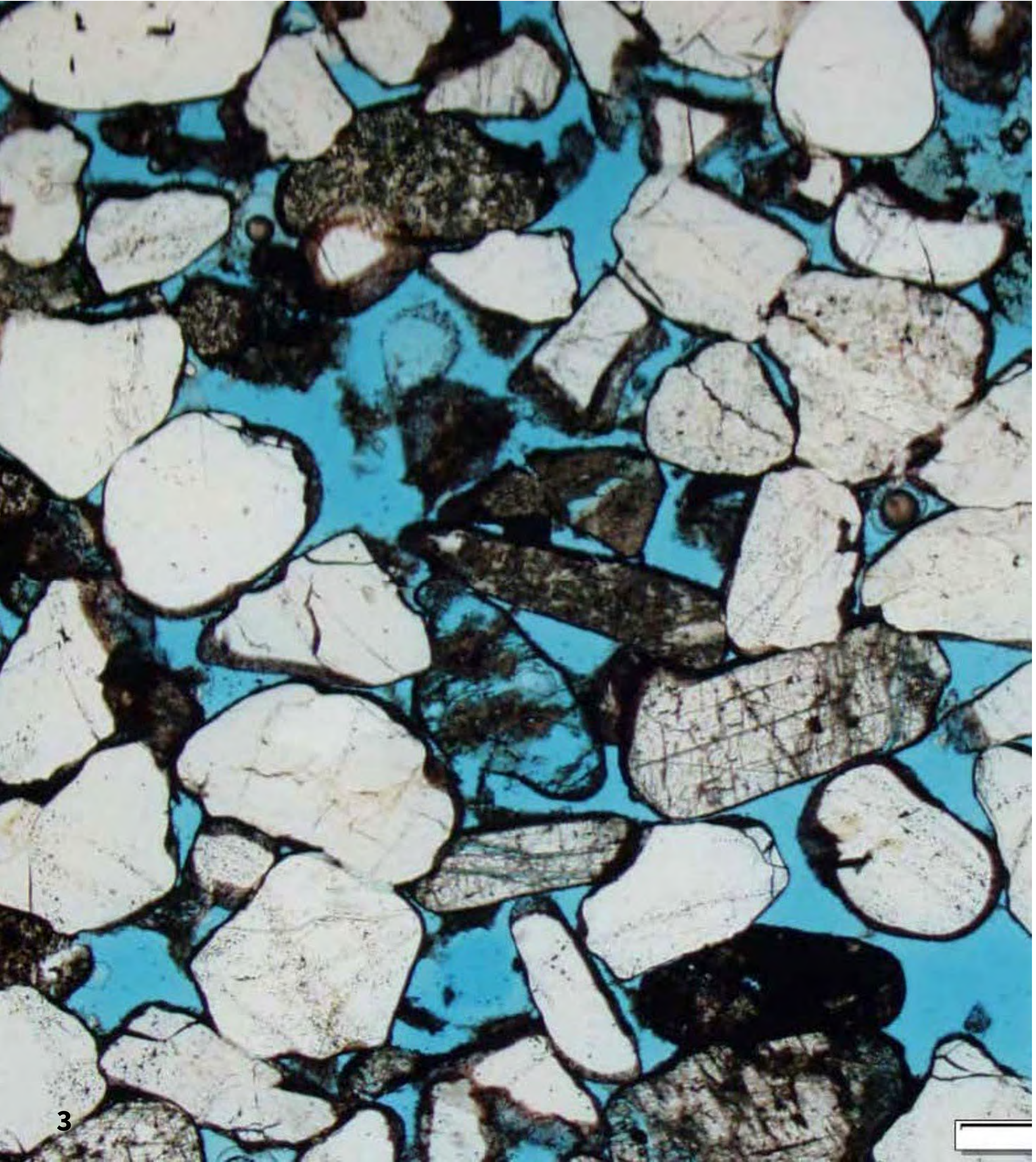

# THE EARTH STORES WATER, SALINE WATER, OIL, AND NATURAL GAS IN PORE SPACES OF ROCK UNITS



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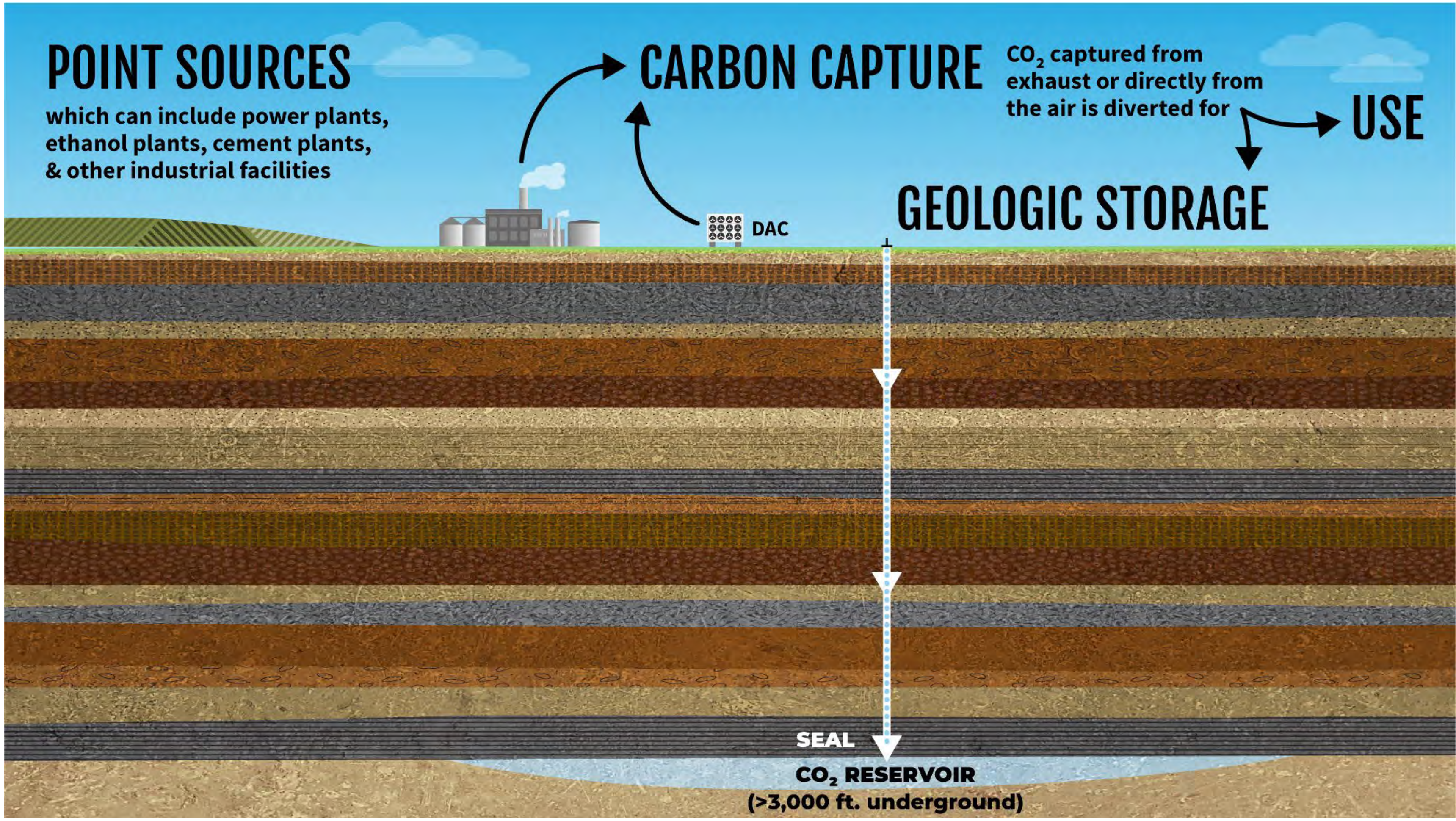
# CARBON CAPTURE UTILIZATION AND STORAGE (CCUS)

- Recognized as an effective means of achieving mid-century emissions reduction goals
- Transitional technologies to allow the world to reduce carbon emissions on the path to net zero




**REPORT: CCUS in Illinois, PRI, 2022**

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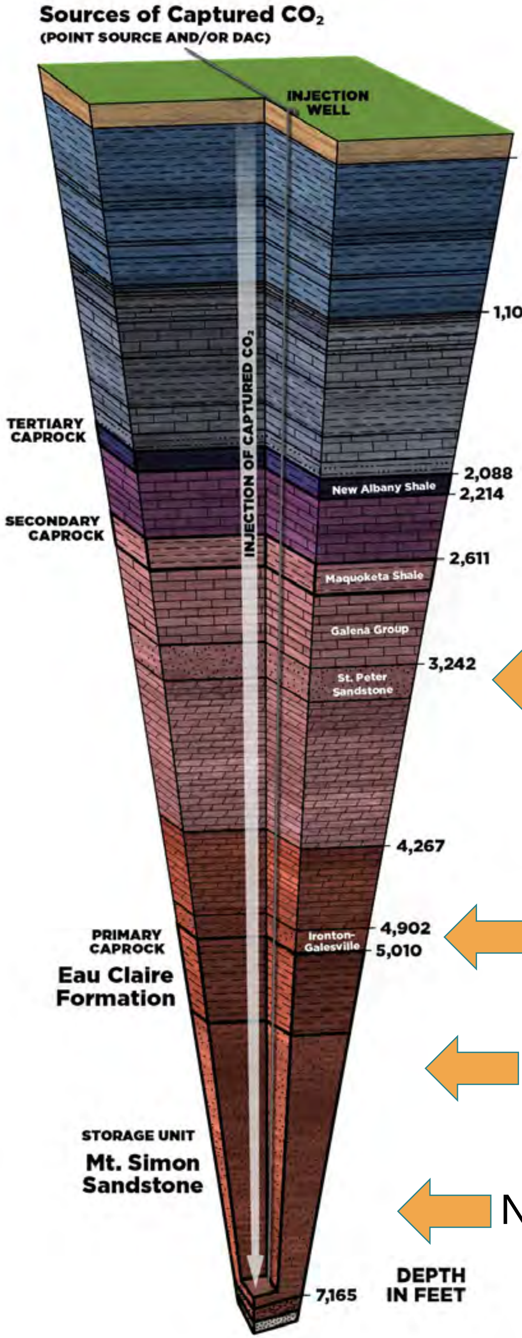
# ILLINOIS BASIN GEOLOGY

## (NEAR DECATUR, IL)


= monitoring zones




Shallow aquifers (<200 ft)

Non-potable water

Lowermost Underground Source of Drinking Water (~3,300 ft)

Non-potable water (~5,000 ft)

Non-potable water (~5,700 ft)

Non-potable water (~6,600 ft)

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# MAHOMET AQUIFER PROTECTION

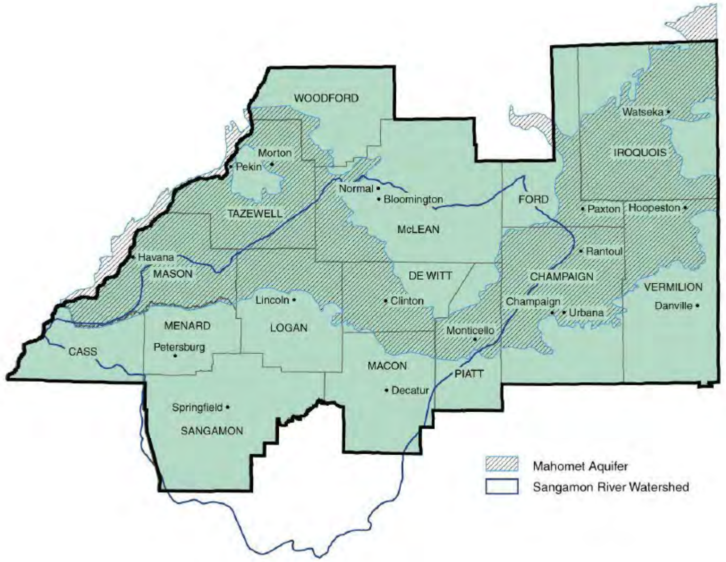
In 2018, the **Mahomet Aquifer Protection Task Force identified current and potential contamination threats** to the water quality of the Mahomet Aquifer, including:

- **Potential routes** (abandoned wells)
- **Potential threats** (legacy landfills)
- **Threats** (nitrate, arsenic, road salt, inadequate source water protection, household hazardous waste, pharmaceuticals and personal care products, underground natural gas storage)

## MAHOMET AQUIFER PROTECTION TASK FORCE: FINDINGS AND RECOMMENDATIONS

*Published Dec. 21, 2018*

*Authored by Task Force members Carol Ammons, Eric Ballenger, Teresa Barnett, Scott Bennett, Alec Davis, Deborah Frank-Feinen (chair), Keith Gleason, Donovan Griffith, Charles Hostetler, Lynn Karner, Chris Koos, Claudia Lennhoff, Diane Marlin, Alec Messina, Bill Mitchell, Julie Moore-Wolfe, Andrew Rehn, Jim Risley, George Roadcap, Chapin Rose, Charles Smith, Larry Stoner, Steve Turner, Todd Zalucha, and David Zimmerman with additional support from Rick Cobb, Illinois EPA; Randy Locke, Illinois State Geological Survey; and Walt Kelly, Illinois State Water Survey*



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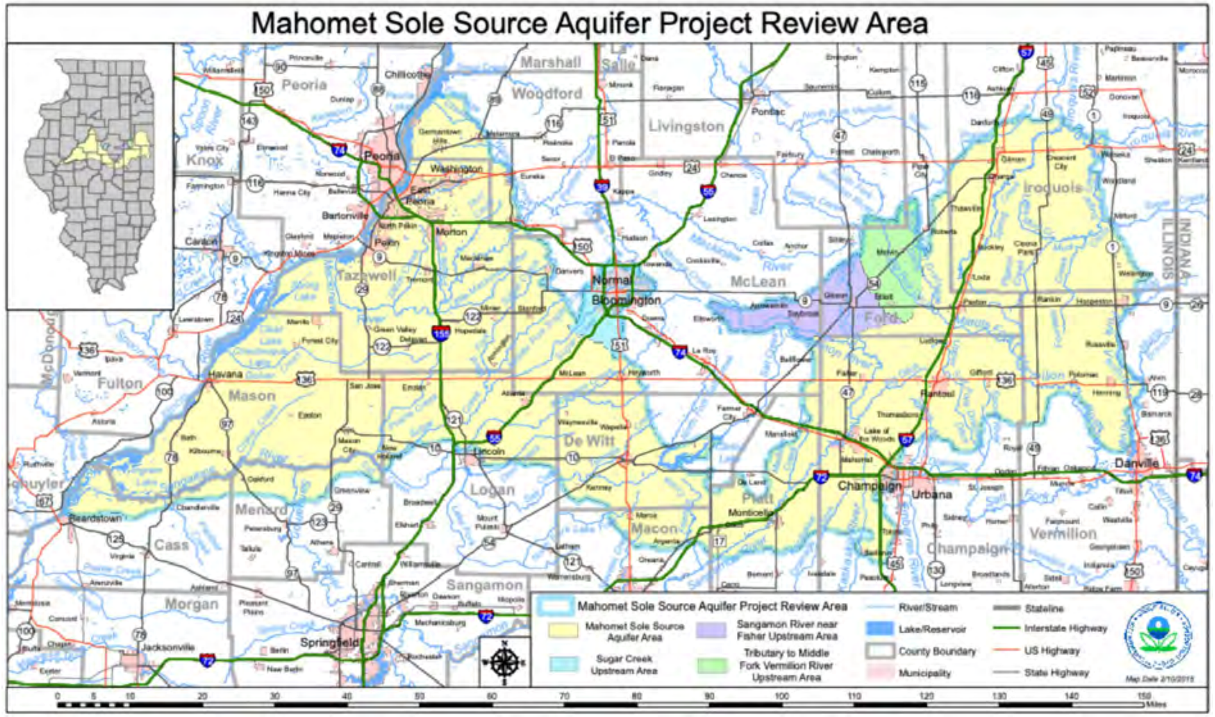
# EXISTING WELLS WITHIN THE MAHOMET AQUIFER SOLE SOURCE AREA

| Well type Category | Number | Percent |
|---:|---:|---:|
| Water | 19,836 | 81.5% |
| Engineering | 1,963 | 8.1% |
| Structure Test | 720 | 3.0% |
| Environmental | 586 | 2.4% |
| Oil | 451 | 1.9% |
| Gas Storage | 320 | 1.3% |
| Coal Test | 318 | 1.3% |
| Other | 137 | 0.6% |

- 24,331 well bores
- 95% less than 400 ft deep
- No carbon dioxide injection wells
- Analysis by N. Webb and D. Garner ISGS well data, December 2024

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# UIC CLASS VI WELL PERMITTING

- The primary goal of the federal UIC Class VI regulations is to ensure that underground sources of drinking water are not contaminated by injected carbon dioxide
- Key Requirements:
    - Plans that document siting, infrastructure, operations, monitoring, post closure, emergency response, and financial assurance for a proposed project
        - Site Suitability: Only geologically suitable sites qualify
        - Well Construction Standards: Use of approved design and materials
        - Monitoring Protocols: Regular groundwater monitoring to detect and mitigate issues
- Protects potable groundwater sources, like the Mahomet Aquifer, from potential risks
- Ensures transparency and accountability through periodic reporting to the USEPA

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# Class VI Permitting Process

**Permit application submission**

**Permit to construct**

**Authorization to inject**

**Injection ceases**

**Site closure**

## 1. Pre-construction

- EPA performs completeness evaluation and technical review of application materials
- EPA makes draft permitting decision (denial or permit issuance)
- Draft permit is public noticed
- EPA prepares final permit decision

## 2. Pre-Injection

- Well owner or operator (o/o) constructs well
- Well o/o collects additional data per permit requirements and submits data to EPA
- EPA reviews additional data and evaluates whether authorization to inject is appropriate

## 3. Injection

- Well o/o collects monitoring data and submits reporting data to EPA
- Permit is updated as appropriate

## 4. Post-Injection

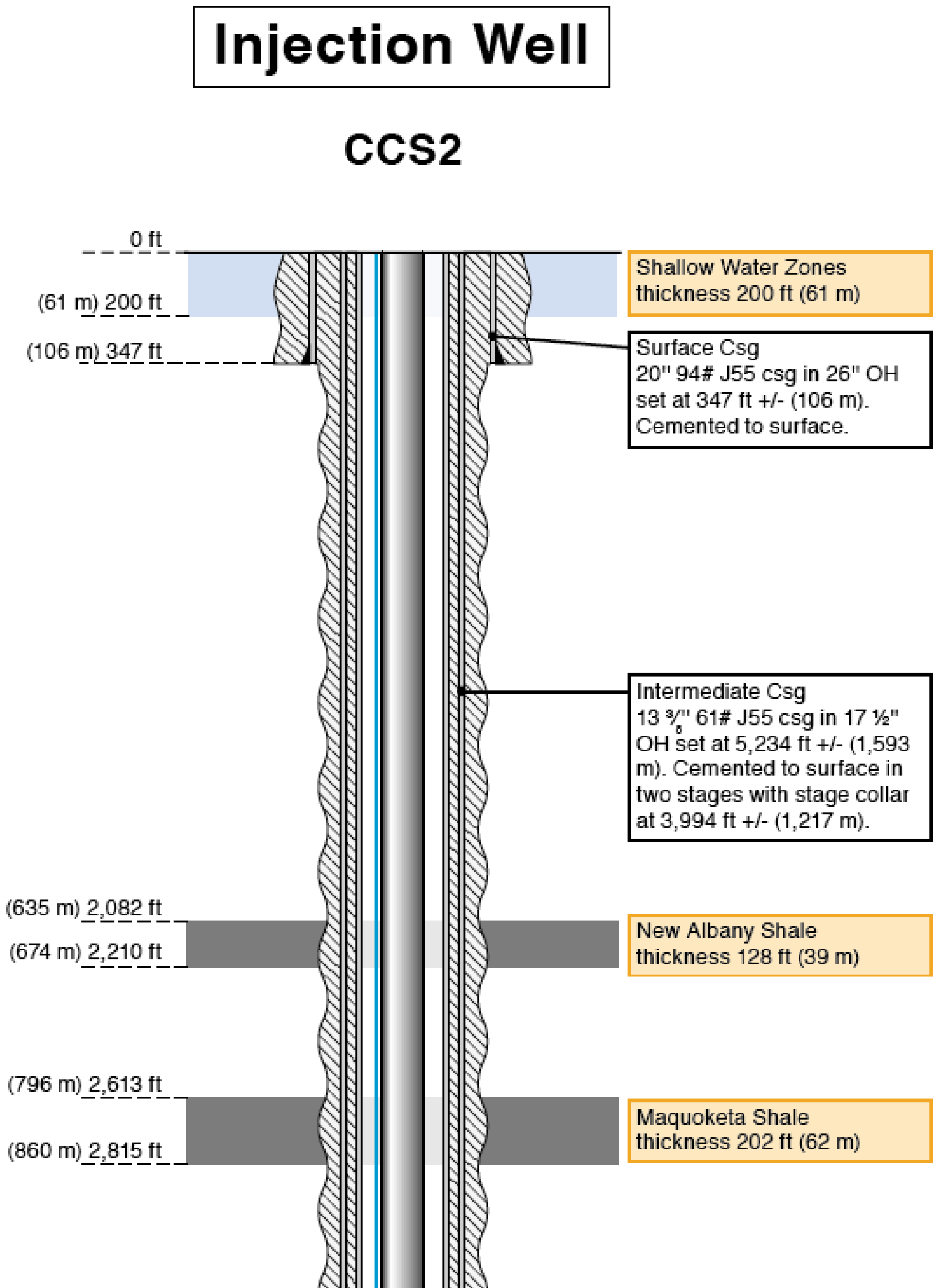
- Well o/o continues to collect monitoring data and submits reporting data to EPA
- Permit is updated as appropriate
- Well o/o demonstrates non-endangerment to EPA
- EPA approves site closure

EPA UIC Class VI Website: https://www.epa.gov/uic/class-vi-wells-used-geologic-sequestration-carbon-dioxide

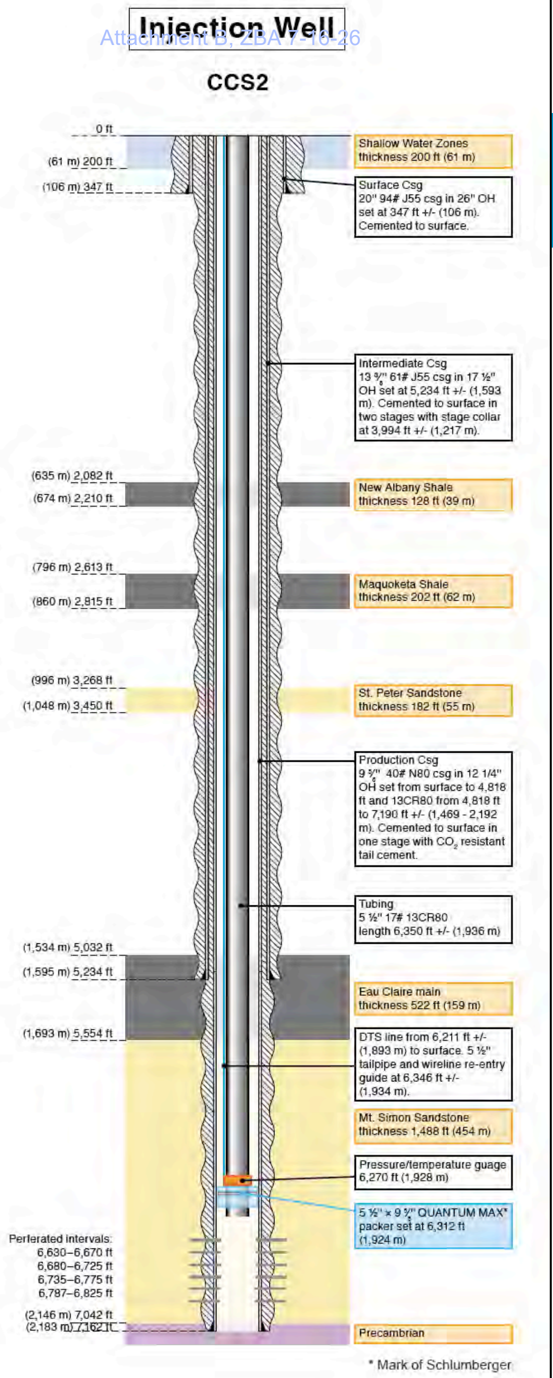
# WELL DESIGN & RISK MANAGEMENT

# INJECTION WELL DESIGN

- Use international standards based on decades of well engineering
- Materials meet or exceed standards set by the American Petroleum Institute (API) and American Society for Testing and Materials (ASTM) International
- In zones near drinking water sources, multiple layers of protective steel casing and cement are used to isolate $CO_2$ from surrounding environments
- Example: Decatur Well CCS2





# RISK MANAGEMENT AND KNOWLEDGE SHARING

- A thorough risk assessment process was part of the Illinois Basin – Decatur Project (Hnottavange-Telleen, 2014)
  - **123 Features, Events, and Processes (FEPs) listed**
  - **88 scenarios incorporated into site design and operation**

- Monitoring well design at the Decatur storage site was unique and it is **not used in** other Class VI applications

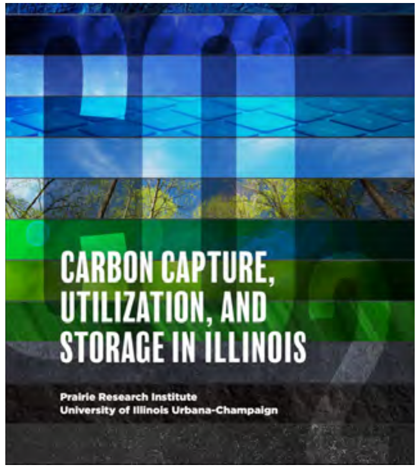
- Knowledge from Illinois has been provided at local to international levels to support informed decision making, regulation, policy, and standards

## Illinois CCUS study group

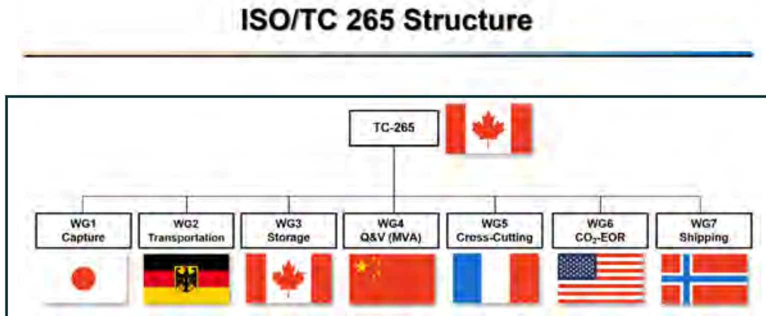
Public Act 102-0341

## PRI CCUS Report

https://hdl.handle.net/2142/116416




**International standards on carbon dioxide capture, transportation, and geological storage**




**~ 40 Participating Countries**

# KEY POINTS

- State (Illinois SAFE CCS Act) and federal (UIC Class VI) permitting prioritize groundwater protection and safe storage
- The risk to the Mahomet Aquifer from carbon storage operations remains low due to siting, data collection, regular reporting, and long-term monitoring requirements
- With 15 years of monitoring to date, PRI has found no evidence of negative impacts from carbon storage to potable groundwater quality

PRI CCUS point of contact:

**Tiffany Jolley**

Assistant Director for Strategic Communications

Prairie Research Institute

tjolley2@illinois.edu | 217-300-2356



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# Illinois' Experience with Carbon Capture and Storage

**STAKEHOLDERS ASKED**

**What's the history of CCUS in Illinois?**

ISGS has been conducting research on the characterization of geological carbon storage sites in Illinois for more than 20 years and the geology of Illinois since 1905. This activity has resulted in scientists and engineers in Illinois developing extensive knowledge and expertise in carbon capture and storage and in Illinois having some of the most detailed data for site characterization available.

**STAKEHOLDERS ASKED**

**Is all of Illinois' geology alike?**

The carbon storage experience in Illinois includes site screening studies, demonstration of $CO_2$ injection, and commercial-scale operations. Much of this work has been supported through U.S. DOE-sponsored projects led by, or involving, the Prairie Research Institute (PRI). Several of the carbon storage projects are summarized below.


**FIGURE 14.** Outline of the Illinois Basin, a geologic subsurface feature. The Illinois Basin is a massive oval depression that underlies roughly 70 percent of Illinois, extending about 60,000 square miles. Since the early 2000s, there has been strong interest in using the unique geology of the Illinois Basin to permanently store, or sequester, carbon dioxide ($CO_2$). The Mt. Simon Sandstone was among the first strata used to store $CO_2$, and the focus of the United States' first commercial-scale carbon sequestration project, the Illinois Basin — Decatur Project (IBDP).

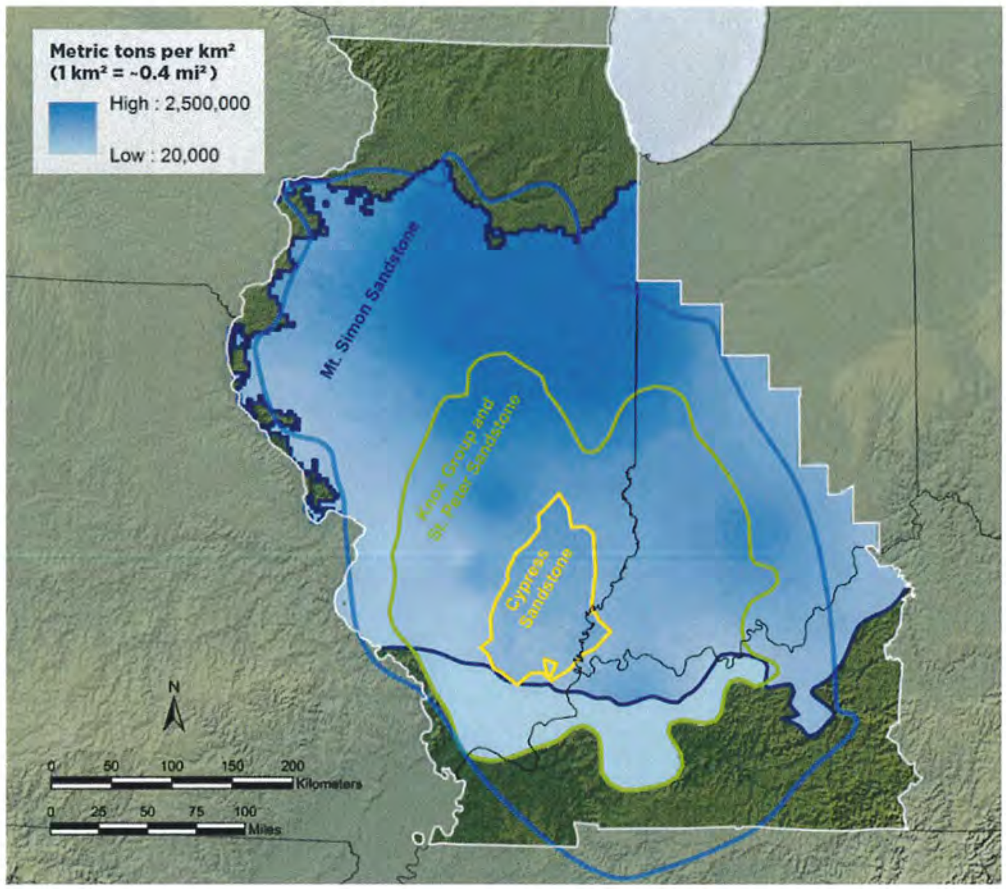


**FIGURE 15.** $CO_2$ storage resource for deep saline formations in the Illinois Basin region (modified from U.S. DOE, 2012). Map shows the regional storage resource within the project area (white outline) for the Mt. Simon, St. Peter, and Cypress Sandstones, and is largely a function of formation thickness and average porosity over areas where the formations are individually deeper than 2,500 feet (a general depth which represents minimum pressure and temperature conditions adequate to maintain $CO_2$ in the supercritical state). Note the Knox Group carbonates are not included in this resource tabulation, but their availability for storage generally follows the depth trend of the overlying St. Peter Sandstone. The regional map will be updated based on new data available after the time of its publication.

ILLINOIS

Prairie Research Institute
Illinois State Geological Survey
615 E. Peabody Drive, MC-650
Champaign, IL 61820-6918

February 27th, 2026
Champaign County Board
Scott M. Bennett Administrative Center
102 E. Main Street
Urbana, IL 61801

Dear Ms. Kathy Larson,

Please accept this draft version of the final report as the Illinois State Geological Survey (ISGS) deliverable for fulfillment of contract AJ586: Geophysical Mapping of the Mahomet Aquifer using Airborne Electromagnetic Method with Champaign County Board.

Upon review and acceptance of this report, please provide a letter to the ISGS confirming your approval. If you require any further clarification of the details in the report or would like information added/removed please contact us. We are willing to meet with you to provide further explanation about the contents in the report, the organization of the information presented, and more information on geology and geophysics.

Your letter of approval will be forwarded to the Contract and Grants Office at the University of Illinois at Urbana-Champaign in order that the contract can be closed.

Best regards,

Kisa Mwakanyamale Gilkie, Ph.D.
Associate Geophysicist
Principle Investigator
Illinois State Geological Survey

# Geophysical Mapping of the Mahomet Aquifer using Airborne Electromagnetic Method

by Kisa Mwakanyamale Gilkie, Donald A. Keefer, Jason F. Thomason, Steven Young, and Andrew J. Stumpf

Submitted under contract to:

Champaign County Board
Kathy Larson, Economic Development Specialist, ARPA Project Manager
Contract No. AJ586

2026

Prairie Research Institute
Praveen Kumar, Executive Director
ILLINOIS STATE GEOLOGICAL SURVEY
Steven Brown, Director
615 East Peabody Drive
Champaign, Illinois 61820-6964

# Table of Contents

## ACKNOWLEDGEMENTS

This report was funded by Champaign County under contract AJ586: Geophysical Mapping of the Mahomet Aquifer using Airborne Electromagnetic Method. We thank the Champaign County Board for their support of this project. We are especially grateful to Richard Berg, Director, Steven E. Brown, Interim Director and State Geologist, and Christopher Stohr for their support of this project from inception, and their continued support in spreading the word on the use of HTEM for aquifer mapping in east-central Illinois. We also thank many State legislators, local leaders and the Champaign County First group for their support of this project and help in acquiring funds for the Mahomet aquifer mapping project including, Senators Chapin Rose, Carol Ammons, and Scott Bennett, Mayor Diane Marlin, and Mayor Deborah Frank-Feinen. We thank the Mahomet Aquifer Consortium and other advocacy groups for advocating for the sustainability of the Mahomet aquifer as a groundwater resource.

We thank many scientists and staff members across ISGS who have provided insights into the Mahomet aquifer and the geology of east-central Illinois in general, including Riley Balikian for helping in acquiring and processing additional HVSR data, Timothy Larson for the careful review of the HTEM, ERT, and borehole data across Champaign County, and Deette Lund for the thoughtful review of this manuscript, formatting, and graphics. We also thank Dr. Flemming Jørgensen of the Geological Survey of Denmark and Greenland Bulletin for providing critical insight on the processing and interpretation of HTEM data, including guidance in the development of the Material Type Characterization method that was developed for this project. We thank Daniel Abrams and Daniel Hadley of the Illinois State Water Survey for consulting with us during the geological modeling stage.

The authors are very grateful to the many student interns from the University of Illinois Urbana-Champaign and Illinois State University for their help in field data acquisition during the summer. We thank many motivated citizens, including Chris Bolt, for allowing us to drill on his property in Sydney, Illinois. The Prairieview-Ogden School District is also thanked for allowing us to drill on their property in the unincorporated area of Flatville, Illinois. We also thank the ISGS staff who provided drilling services.

# EXECUTIVE SUMMARY

An important mission of the Prairie Research Institute (PRI) is to bridge the worlds of applied geosciences and policy. PRI provides decision makers with science-based knowledge of natural resources. Groundwater science, in particular, is aimed at explaining aquifer systems by implementing objective, standardized scientific tools and methods. Unfortunately, the policy of managing groundwater resources often depends on subjective interests. Thus, integrating new scientific methods and clear communication strategies is key to keeping stakeholders and the public informed. Implementing scientifically informed policy associated with the Mahomet aquifer will have positive impacts on the quality of life, water security, sustainability, and risk. Furthermore, successful science-based policy can greatly advance the progression of fundamental science.

This report summarizes the results of a three-year project commissioned by Champaign County directing the Illinois State Geological Survey (ISGS) to study, in high resolution, the framework and geometry of the Mahomet aquifer within the jurisdiction of Champaign County. This project uses high density helicopter-borne time-domain electromagnetic measurements (HTEM) to provide reliable data with which Champaign County can formulate effective and sustainable strategies to protect groundwater resources and the economy of the county. The main objectives of this project are to: 1) improve delineation of the Mahomet aquifer boundary in Champaign County; 2) better define, in high resolution, the extent of aquifer and non-aquifer units; and 3) develop a 3-D geologic model of Champaign County and create an updated geological framework. County-scale maps illustrating results from the project show the distribution of geologic aquifer and non-aquifer materials, later defined as aquifer units and confining units. Understanding the geometry and the general make-up of these aquifer and confining units will facilitate decision making regarding the protection and sustainable management of this critical groundwater resource in the county.

For this project we used traditional geophysical methods including ground-based electrical resistivity tomography (ERT), seismic reflection, horizontal-vertical spectral ratio (HVSR), and borehole information to complement an advanced airborne geophysical method, HTEM. These traditional ground-based geophysical methods were specifically used in areas where HTEM data could not be collected (e.g., in cities and other populated areas); and in other instances, they were used to confirm the HTEM results (in this case, the use of borehole information). This report describes the methods used by the ISGS to collect newly acquired geophysical data, and the processes used to analyze and interpret these data. The geological and geophysical data acquired were the basis for developing geologic models. A summary that describes how the data were used to construct a 3-D geologic model of the project area is provided. Hydrogeological implications of the modeling are also described.

Approximately 3,145 km (1,954 miles) of HTEM data were collected within Champaign County, extending from the Ford County/Champaign County border in the north, between County Road

500 and County Road 400, north of the Village of Pesotum in the south. We also acquired a total of 4.3 miles of 2-D ERT data, and total of 15.66 kms (9.72 miles) of 2-D seismic reflections data on several roadways in Champaign County. Distribution of the ERT and seismic profiles depended on HTEM data coverage and the need to complement HTEM data. Additionally, a total of 180 HVSR points were collected inside Champaign County between the summers of 2023 and 2025, and two new boreholes were drilled in the unincorporated areas of Flatville and Sydney, Illinois.

Findings from this report provide a more refined bedrock topography, which is the basis for the Mahomet Bedrock Valley that houses the Mahomet aquifer. This newly mapped bedrock valley indicates that the general pattern of this topographic map is more variable than that seen on traditionally made maps. Maps illustrating the newly defined Mahomet aquifer boundary, geological materials inside the aquifer boundary, and the thickness of Mahomet aquifer, are all described in this report. Perhaps more importantly are the maps illustrating distribution of all the aquifer in Champaign County and the interconnectivity of these aquifers with the Mahomet aquifer, answering important questions pertaining to groundwater quality, quantity, availability, and recharge. The delivered data includes processed HTEM data and presentations, interpreted results, and model presentations. All figures created during data processing and interpretation will be included in the digital data delivery.

# 1. INTRODUCTION

## 1.1 Mahomet Bedrock Valley (MBV)

The most prominent, but hidden, geological feature in Champaign County is the Mahomet Bedrock Valley (MBV); a preglacial bedrock valley infilled and deeply buried by glacial deposits. This ancient preglacial landscape feature formed hundreds of millions of years ago and is part of a drainage system incised into the ancient bedrock surface that crosses Illinois and eastern North America. These bedrock valleys are largely filled and buried by up to hundreds of feet of glacial deposits of the most recent, Pleistocene glaciations. In particular, the MBV was once part of an extensive mid-continental preglacial drainage system known as the Teays-Mahomet Bedrock Valley System (Melhorn and Kempton 1991), which, during the Late Tertiary and Early Pleistocene, drained the Appalachian Mountains westward to the Gulf of Mexico (Horberg 1945).

The MBV underlies portions of 14 counties in east-central Illinois, from near the modern Illinois River, east to the Illinois/Indiana State line. The MBV does not appear to be aligned with any known bedrock structural feature, fracture pattern, or change in lithology. Rather, along its 125-mile course in Illinois, the MBV was incised across prominent regional structural features and lithologic boundaries. For example, in Champaign County, the MBV transects the LaSalle Anticlinorium, which is a belt of domed and folded rocks that extends northwestward from the Village of Pesotum through northwest Champaign County (Nelson, in press; Kolata 2005). The LaSalle Anticlinorium extends farther northward into north-central Illinois. While the bedrock entrenchment in Champaign County is relatively shallow, the deepest channel in the MBV is 200–300 feet lower than the surrounding landscape and has historically been mapped in the subsurface between the 300- and 500-foot above sea level (asl) contours (Kempton et al. 1991). The deepest channel has been known, informally, to well drillers since the 1930s. Horberg (1945, 1950) first mapped the MBV (Figure 1) and built the framework for mapping other bedrock valleys in Illinois. In east-central Illinois, the MBV generally ranges from 5 miles wide in central Piatt County to almost 20 miles wide in eastern Champaign and Ford Counties. A few broad benches (bedrock terraces) have been identified along the MBV (Kempton et al. 1991). They are especially well developed in northeastern Champaign County and northern Vermilion County between elevations 400 and 450 feet asl, and between 450 and 500 feet asl in southwestern Iroquois County. These terraces indicate periods when bedrock erosion rates increased, which left former topographic benches abandoned at higher elevations.

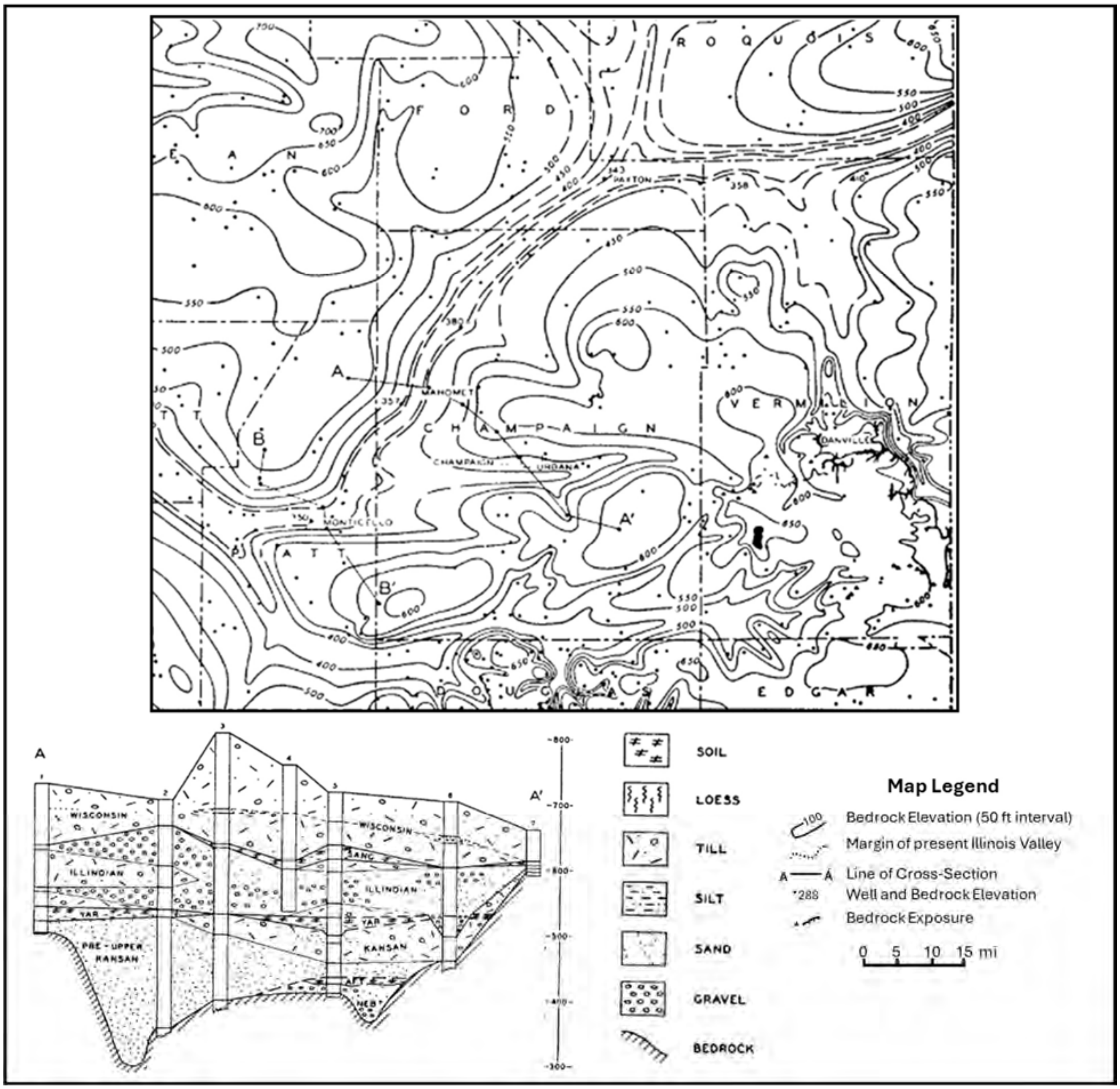


**Figure 1**. Bedrock topography and geologic cross section of glacial deposits in east-central Illinois. The course of the Mahomet Bedrock Valley (MBV) shows prominently on the bedrock surface in cross section the sediments deposited during the Wisconsin, Illinois, and pre-Illinois glaciations. Figure modified from Horberg, 1945.

Several glaciations have impacted Illinois over the past 1 million years. The glaciations are named the Wisconsin Episode (60,000–14,700 years ago), the Illinois Episode (200,000–130,000 years ago) and the pre-Illinois Episode ~1,200,000–420,000 years ago). The glacial sediments that infill the MBV are generally associated with Illinois and pre-Illinois Episode glaciations (Stumpf and Atkinson, 2015). The sediments from these glacial events differ in lithology, thickness, and extent, which has been used to help categorize them into different, mappable, geologic (lithostratigraphic) units (Kempton et al. 1991; Stumpf and Dey 2012). For example, deposits of pebbly, medium to coarse sand and gravel often found along the lowest part of the

MBV, deposited during earliest (pre-Illinois Episode) glaciation, have historically been associated with the Mahomet aquifer, which is the primary groundwater resource for 15 counties in the east-central Illinois. Although the geological heterogeneity in the MBV has been described in numerous geologic and hydrogeologic reports (for example, Kempton et al. 1991; Langenheim and Nelson 1992; Visocky and Schicht 1969; Herzog et al. 1995, 2003; Berg and Abert 1994; McLean et al. 1997; Soller et al. 1999; Wilson et al. 1998; Roadcap et al. 2011; Stumpf and Dey 2012 and Stumpf and Atkinson, 2015; Brown et al. 2018). Our understanding of its origins and subsequent burial is continually evolving as new data are obtained and analyzed.

### 1.2 Problem

Given the need to improve our understanding of the available groundwater resources in Champaign County and the flow of groundwater within the Mahomet aquifer and other aquifers in the area, Champaign County contracted Illinois State Geological Survey (ISGS) to complete a high-resolution geophysical study of the Mahomet aquifer within the jurisdiction of Champaign County. The long-term sustainability of available groundwater resources is a growing problem in many regions of the United States due to excessive groundwater withdrawals (Konikow 2015). Increased withdrawals are generally a function of population growth, increased frequency of droughts, industrial growth, and increased agricultural demand (e.g., Alley et al., 1999). In 2015, groundwater extraction from 66 principal aquifers (as defined by the U.S. Geological Survey) in the United States totaled 79,200 Mgal/d (Lovelace et al. 2020). Of the water withdrawn from these principal aquifers, 81% (63,900 Mgal/d) was from unconsolidated and semi-consolidated sand and gravel aquifer systems. Thus, glacial sand and gravel aquifers found in buried bedrock valleys are an important subset of the unconsolidated aquifers (Figure 1). In east-central Illinois, the Mahomet aquifer supplies approximately 220 Mgal/d of water to communities, agriculture, industry, and rural wells in a region having a total population of ~1 million people (Ammons et al. 2018). Improving our understanding of the 3-dimentional (3-D) geometry of the sediments filling the MBV, the distribution and complexity of the Mahomet aquifer, and the connections to adjacent watersheds and geologic formations is one of the best ways to improve long-term planning of our groundwater resources.

Results from this project are used to create integrated predictive models that can be used to improve the accuracy of groundwater models for improved resource management and protection. Collectively, this work will provide support for sustainable water-supply planning strategies that protect public health and help grow local economies when impacted by increased water demand due to population growth (Figure 2), changing climate conditions, and other large demand stresses (e.g., industrial expansion and data centers). Water security is critical for maintaining community sustainability, public health, and economic security. This project implemented rapid data collection techniques and state-of-the-art science-based data analysis methodologies to better resolve the boundaries and internal complexities of aquifers. The results of this project also provide a critical basis for water managers and stakeholders to ensure the security of the water supply for such instances ranging from localized over-use to contamination.

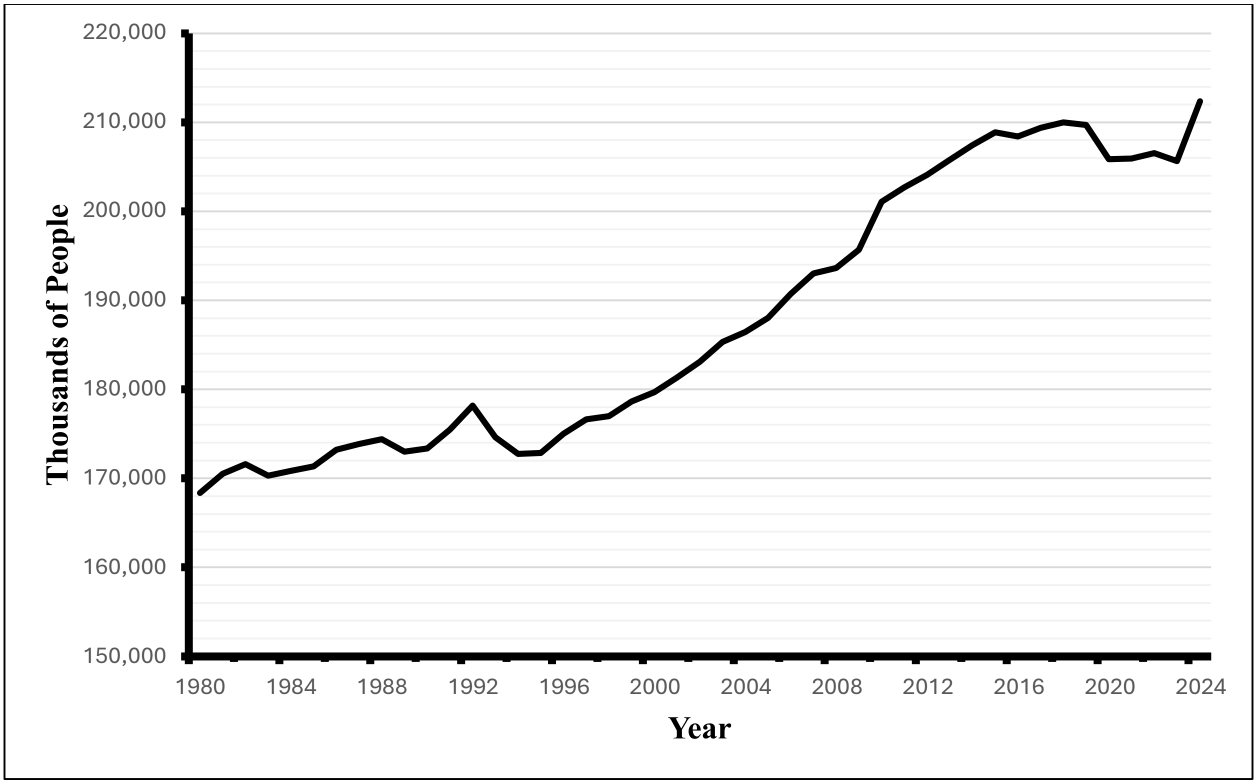


**Figure 2**. Population in the Champaign-Urbana metropolitan area from 1980–2024. Data are from the U.S. Census Bureau (U.S. Census Bureau 2025).

For years, ISGS scientists and colleagues have focused their time and resources on improving our understanding of the Mahomet aquifer. These studies have included the collection and analysis of high-quality ground-collected data. These data typically include lithological descriptions from drilling logs (Kempton et al. 1991; Stumpf and Dey 2012), borehole geophysical logs (Ismail et al. 2013; Stumpf and Ismail 2013), and electrical and seismic geophysical profiles (Foster and Buhle 1951; Buhle and Brueckmann 1964; Larson et al. 1997; Pugin et al. 2003, 2004). The most recent studies, Soller et al. (1999), Pugin et al. (2003, 2004), Stumpf and Dey (2012), and Stumpf et al. (in review) improved our understanding of the heterogeneity in the geology of the MBV and resolved isolated bodies of sand and gravel that were deposited during the different glacial episodes. However, there are still large portions of the MBV, including many areas where the Mahomet aquifer is present, that have not been studied in detail. Even though decades of research have provided important insights into the geology of the MBV, the data resolution is not uniform (i.e., data points are clustered or far apart). In particular, maps of the local complexities of the MBV are still incomplete. To address these issues, this project used an advanced airborne data collection technology that exponentially increased the data resolution across the MBV area, which drastically improved the resolution of subsurface geologic maps.

## 2. OBJECTIVES

The sustainable availability of an adequate and high-quality groundwater supply is essential for public health, environmental protection, and economic development. With a growing population (Figure 2) and changing climate, groundwater resources and their supply planning are becoming increasingly complex. This led the Champaign County Board to fund a three-year program for high-resolution mapping of the Mahomet aquifer within Champaign County. Our current understanding of the distribution and characteristics of the Mahomet aquifer in Champaign County is based largely on information collected from drilling and some ground-based geophysics, for example electrical resistivity and seismic data, reported by Stumpf and Dey, (2012), Ismail et al. (2013) and Stumpf and Ismail (2013). This approach has been used in geologic mapping for decades but is limited by low resolution and a sparce dataset. While information obtained from drilling is the most accurate, significant distance between boreholes adds a degree of uncertainty to the interpolation upon which the resulting maps and models are based.

This project focused on the use of state-of-the-art airborne geophysical mapping technology to greatly improve data resolution and subsurface information associated with the Mahomet aquifer. Thus, these data were used to greatly improve the resulting geological mapping, geological models and, especially, the hydrogeological framework of the Mahomet aquifer. The major objectives of this project were to:

I. **Improve delineation of the Mahomet aquifer boundary**
There are currently two published boundaries: (1)Mahomet Aquifer System, defined by the U.S. Environmental Protection Agency (USEPA) in its 2015 sole-source designation (USEPA, 2015); and (2) Mahomet aquifer defined by the Illinois State Water Survey (ISWS) (Roadcap et al. 2011), currently used to constrain regional groundwater flow models within the MBV, and coincides with the top of the MBV and Mahomet aquifer. This boundary historically has been delineated by the 500-foot elevation contour line. However, a few studies of the Mahomet aquifer for Champaign County and other parts of east-central Illinois (Kempton et al. 1991; Stumpf and Dey 2012) have interpreted the Mahomet aquifer to extend above the 500-foot elevation contour. Most recently, a third Mahomet aquifer boundary was interpreted in Champaign County through use of traditional and ground-based 3-D mapping methods. While this is an informal boundary (i.e. not for public use) that has not been published or undergone administrative review by the ISGS, it includes additional modifications to the USEPA 2015 and Roadcap et al. (2011) boundaries. The high-resolution geophysical data acquired for this project will be used to better delineate the boundary of the Mahomet aquifer.

II. **Better define extent of aquifer and non-aquifer units**
Understanding the detailed character of the geologic materials found over the MBV is key to understanding the storage capacity and possible groundwater flow patterns. Studies done in east-central Illinois by both the ISGS and ISWS on the Mahomet aquifer

have repeatedly demonstrated the presence of layers of non-aquifer materials within the deposits considered to compose the upper and Lower Glasford Aquifers and the Mahomet aquifer. For example, the complex nature of the glacial deposits overlying the bedrock surface is well documented by Stumpf and Dey (2012) and Stumpf and Atkinson (2015). Furthermore, Stohr et al. (2015) demonstrated the complexity of aquifer materials within the glacial sequence of the Illinois Episode that are analogous to the pre-Illinois Episode glacial deposits that infill the MBV (Figure 3). These results are used to improve our understanding of the distribution and proportions of non-aquifer and aquifer units within the Mahomet aquifer.

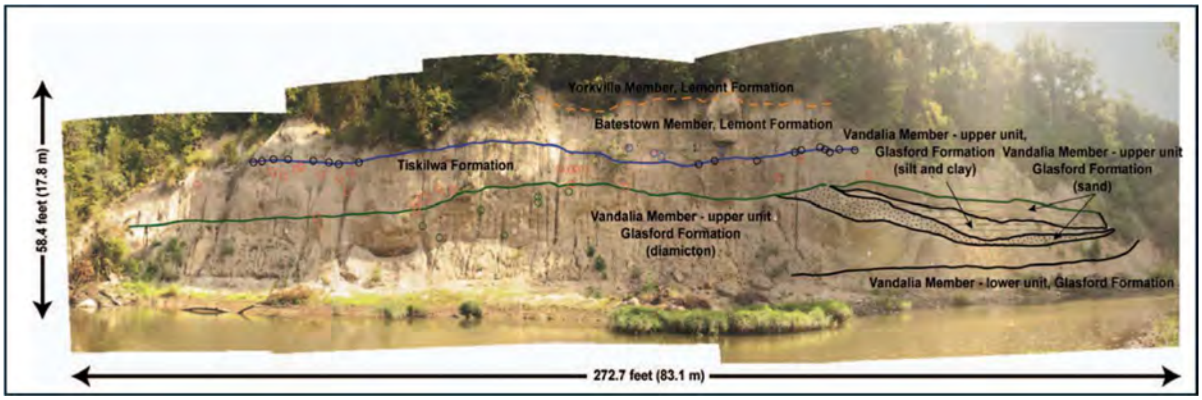


**Figure 3**. Glacial deposits outcropping along the Middle Fork Vermilion River, Illinois (from Stohr et al. 2015). Buried channels filled with sand and gravel within non-aquifer deposits were assigned to the upper part of the Glasford Formation.

## III. Develop a 3-D geological model of the Champaign County and create an updated geological framework

A detailed geologic model of east-central Illinois, including the area underlain by the Mahomet aquifer was developed by Stumpf and Dey (2012). The geological framework accompanying the model incorporated data and interpretations compiled from geological and geophysical studies completed in Champaign County and surrounding areas between 2007 and 2012. This geological framework incorporates aspects of previous lithostratigraphic classifications from Hansel and Johnson (1996), Kempton et al. (1991), Willman and Frye (1970), and Willman et al. (1975). The geologic model developed by Stumpf and Dey (2012) is the most recent depiction of the Mahomet aquifer and used the most updated datasets available at that time.

The data collected for this project will help update the geological framework of Stumpf and Dey (2012) by filling in the large gaps in data between boreholes and ground-based geophysical surveys and increasing the resolution of the geological framework and the estimated proportions (scenarios) of non-aquifer and aquifer units, respectively. These results include a new map of the bedrock topography in Champaign County. Lastly, in collaboration with ISWS, the results from this project (i.e., various iterations of the geologic model) will be used in updating the regional groundwater flow model that guides the water-supply planning effort in Champaign County.

# 3. PROJECT AREA

## 3.1 Previous Work

During the last half century or so, our understanding of the subsurface geology in east-central Illinois has evolved with the collection of borehole and geophysics data (both ground-based and downhole) as part of formal scientific studies and resource exploratory work. These findings are the basis of regional geologic classifications for glacial Pleistocene deposits (e.g., Kempton et al. 1991) and Paleozoic sedimentary bedrock (Langenheim and Nelson 1992). In addition, they are used to delineate and characterize water and mineral resources that are the backbone of the region's social and economic prosperity.

Since the mid-twentieth century, significant research has been undertaken to determine the formation, extent, and characteristics of the MBV and the associated Mahomet aquifer (e.g., Visocky and Schicht 1969; Herzog et al. 1995, 2003). These periodic re-evaluations were undertaken to study drought events and applications for increasing groundwater withdrawals from the Mahomet aquifer.

By the 1970s and 1980s, GIS technologies were introduced for 2-D and 3-D geologic model development and visualization (Berg and Abert 1994; McLean et al. 1997). These studies provided an extensive information base for future cooperative mapping projects (e.g., Soller et al.,1999). Furthermore, in 1993, cooperative studies were undertaken to determine hydrogeological characterization of the glacial deposits (Herzog et al. 1995), and development of a computer-based mathematical model of groundwater flow (Wilson et al. 1998). The ISWS later constructed a larger, regional numerical groundwater flow model of the entire Mahomet aquifer (Roadcap et al. 2011). Subsequently, Stumpf and Dey (2012) and Stumpf and Atkinson (2015) made significant advances in characterizing the MBV and its valley fill by integrating newly acquired data with historical records. A revised geological framework was developed for east-central Illinois.

## 3.2 Geology

The Mahomet aquifer area was glaciated multiple times during the Pleistocene Epoch over the last ~1.2 million years. The glacial sequence, formed from the three glacial episodes, is 200–400 feet thick and completely conceals the deeply dissected bedrock surface, which is a major unconformity directly beneath the glacial deposits (Kempton et al. 1991) (Figure 1). The glacial episodes were preceded by the Pliocene–Early Pleistocene preglacial period, interspersed with warmer interglacial periods (Yarmouth and Sangamon Episodes), and followed by a postglacial period known as the Hudson Episode or Holocene Epoch (Curry et al. 2011). During the nonglacial times, drainage continually adjusted to meet new river base levels, alluvium and lacustrine sediments accumulated in valleys and low-lying areas, and pedological processes formed well-developed soils in thick deposits on the land surface. Surficial sediments were reworked by the actions of wind and water on the land surface.

Land surface topography in Champaign County (Figure 4) is also defined by the action of wind and water and ice. The advances and retreats of multiple ice margins formed till and clay ridges (moraines) and lowland river valleys, some of them filled with sand and gravel, till and silt. These features bear no direct relation to the MBV and bedrock topography in general, and they cross MBV at various angles without change in trend or elevation. The main uplands we see in Champaign County, are the Gifford, Rantoul and Champaign Moraines (Figure 4), predominantly made up of till and clays. The lowlands include portions of two major river valleys in Champaign County. The Sangamon River Valley, in the northwest part of the county, and the Middle Fork River Valley, in the northeast-most part of the county.

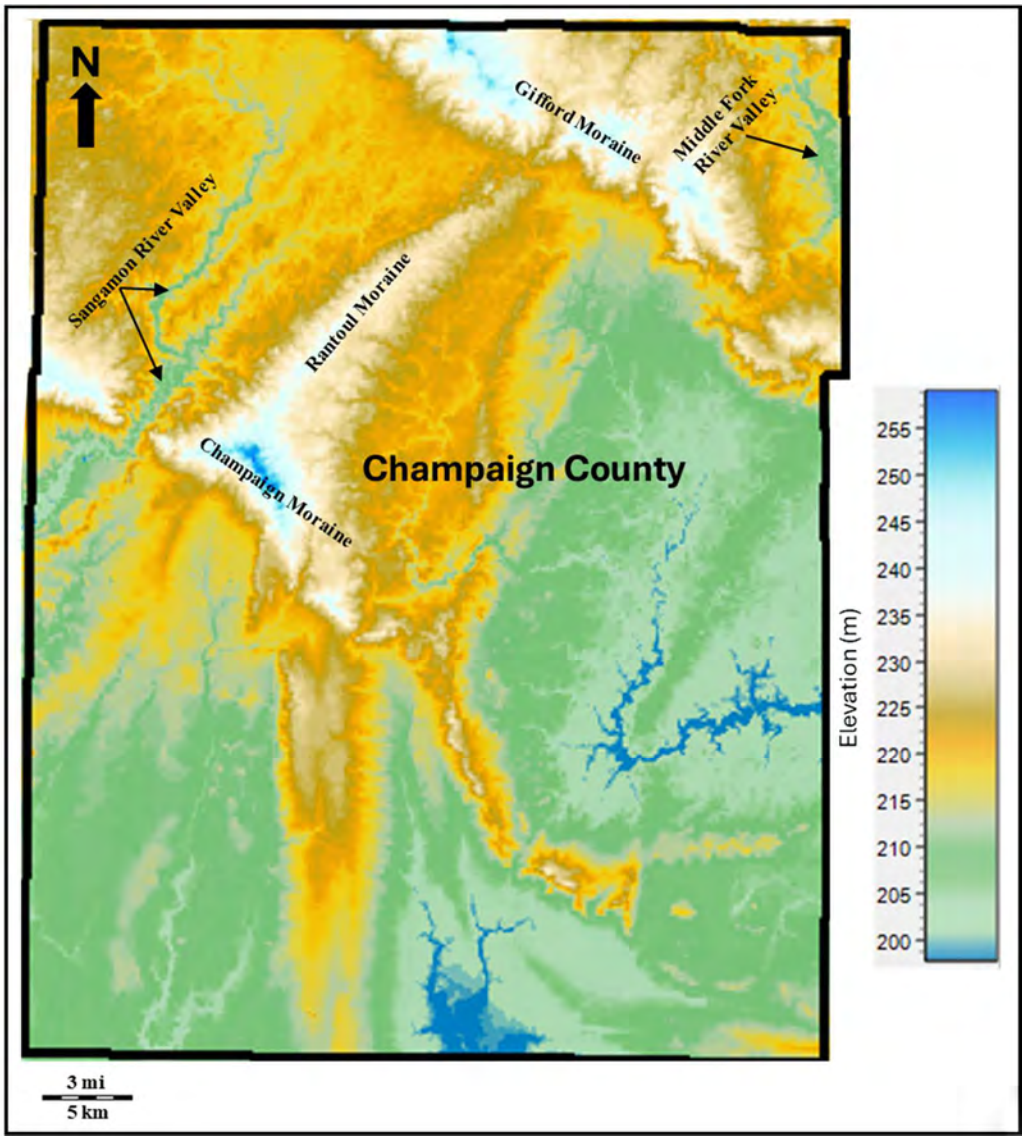


**Figure 4**. Digital Elevation Model (DEM) of Champaign County.

### 3.3 Geological Framework

The geological framework of Champaign County was developed considering geological framework models for east-central Illinois by Stumpf et.al., (in review), Stumpf and Dey (2012), Hansel and Johnson (1996), Willman et al. (1975), and Willman and Fyre (1970). The geological framework for Champaign County includes sedimentary bedrock units, Silurian to Pennsylvanian in age, which are mostly dolomites, shales, and siltstones, Pleistocene-age glacial deposits, and Holocene postglacial deposits. In general, glacial deposits in Champaign County are made up of diamicton (till), silt, clay (lake sediment), and sand and gravel (outwash). These deposits are differentiated based on their physical characteristics (e.g., color, lithology, and mineralogy), stratigraphic position, and age (Kempton et al. 1991; Soller et al. 1999; Stumpf and Dey 2012). In postglacial times, loess (windblown silt and sand) was deposited across the land surface, and alluvium (silt, sand, and gravel) was deposited in river valleys and low-lying areas on uplands (Grimley et al. 2016).

The geological framework includes six geologic units (A to F in vertical profile) from the land surface into the Silurian-age bedrock. **Unit A** represents the postglacial deposits and uppermost glacial deposits of the Wisconsin Episode glaciation, including glacial tills of the Yorkville and Batestown Members (Lemont Formation) and the Tiskilwa Formation, and lake sediment and outwash of the Equality Formation and Henry Formation, respectively. The unit also includes outwash assigned to the Pearl Formation deposited during the Illinois Episode glaciation. **Unit B** comprises dolomite-rich sandy glacial till with layers of sand and gravel, and silt and clay deposited during the Illinois Episode glaciation that were assigned by Stumpf and Atkinson (2015) to the upper and middle units of the Vandalia Member (Glasford Formation).

**Unit C** includes silty glacial till (lower unit) of the Vandalia Member (Glasford Formation), local deposits of silt and clay of the Bellflower tongue (Teneriffe Silt), and deposits of well-sorted sand and gravel, assigned to the Grigg member (Pearl Formation), that are widespread across the MBV and on the adjacent uplands. **Unit D** comprises the clayey tills of the Tilton, Hillery, Harmattan and West Lebanon Members (Banner Formation) deposited during the pre-Illinois Episode glaciation. They overlie or are interstratified with thick deposits of well-sorted pebbly sand and gravel assigned to the Fisher and Rantoul members and Mahomet Sand Member (Banner Formation) in the MBV, and layers of silt, clay, and sand (lacustrine deposits) assigned to the Pesotum, Belgium and Blackford Members (Banner Formation) in the tributary valleys.

**Unit E** is assigned to the gray, massive to vuggy, finely crystalline dolomite, Silurian or Devonian in age, that subcrop on the Mahomet Dome or Rantoul Anticline (Nelson, in press), structural features of the LaSalle Anticlinorium. **Unit F** is distinguished in the HTEM data, and comprises shales, siltstones, limestones, and claystones of Pennsylvanian to Devonian in age that subcrop along the flanks of the LaSalle Anticlinorium and in the southern and eastern parts of the Champaign County (Nelson, in press). This unit also includes the discontinuous preglacial deposits assigned to the Canteen and Dewitt members and weathered bedrock (residuum) of the Oak Formation. These lowermost Pleistocene-age units are included in Unit F because of similar resistivity values, and it is difficult to identify the contact between the lowermost clayey glacial till of the Banner Formation and soft and friable weathered surface of the Pennsylvanian-age shales.

### 3.4 Hydrostratigraphic Framework

The hydrogeology of Champaign County is complex due to the horizontally and vertically heterogeneity between deposits of coarse-grained sand and gravel (aquifer units), and fine-grained, overconsolidated glacial till or deposits of glaciolacustrine silt and clay (non-aquifer, confining units) (Roadcap et al. 2011). Accordingly, aquifers in contemporaneous geologic units can be limited in one area and productive in other areas. Also, aquifers in some places can overlap one another and can be hydraulically connected with each other.

A hydrostratigraphic framework was developed to organize complex and often discontinuous glacial sediments into units with similar hydraulic properties (aquifers and confining units) for use by the ISWS to update the regional groundwater flow model for northeastern Illinois. Grouping hydraulic parameters may be justified for developing regional groundwater-flow models as this may not appreciably sacrifice simulation accuracy (Arihood et al. 2019).

In developing a framework to support the groundwater-flow simulations in the unconsolidated glacial deposits and sedimentary bedrock, ten aquifer and confining units were designated to comprise the six geologic units defined in Section 3.3. The uppermost, **Shallow confining unit**, includes the glacial tills and intervening fine- and coarse-grained sediments and postglacial sediments assigned to Unit A. The **Shallow aquifer** includes the deposits of coarse-grained sand and gravel of the Mason Group (Abrams et al. 2023), including the Ashmore Tongue (Henry Formation), the first coarse-grained sand and gravel deposited during the Wisconsin Episode glaciation, and outwash assigned to the Pearl Formation. The **Upper Middle confining unit** comprises Unit B and lowermost glacial till and fine-grained sediments of Unit A. The **Upper Middle aquifer** includes the intervening layers of coarse sand and gravel of the glacial till assigned to Unit B and well-sorted sand and gravel (Pearl Formation) assigned to Unit C. This aquifer unit would be partly analogous to the upper Glasford Aquifer of Wilson et al. (1998).

The **Lower Middle confining unit** comprises the glacial till of the Glasford Formation and uppermost glacial tills of the Banner Formation and their associated fine-grained sediments of Units C and D, respectively. The **Lower Middle aquifer** is primarily the well-sorted sand and gravel of the Griggs tongue (Pearl Formation) assigned to Unit C and may also include the well-sorted pebbly sand and gravel of the Mahomet aquifer (Unit D). This aquifer is likely analogous to the Lower Glasford Aquifer of Wilson et al. (1998). The **Mahomet confining unit** includes the glacial tills of the Banner Formation and their associated fine-grained sediments (Unit D), and in places silty glacial till (lower unit) of the Vandalia Member and deposits of silt and clay of the Bellflower tongue (Unit C). **The Mahomet aquifer** is primarily the well-sorted pebbly sand and gravel of the Mahomet aquifer (Unit D). In places where the finer-grained sediments of the Mahomet confining unit are absent, Unit D may include the well-sorted sand and gravel of the

Pearl Formation (Unit C). This unit is most likely analogous to the Mahomet aquifer of Herzog et al. (1995).

The **Carbonate confining unit** includes Pleistocene-age preglacial deposits, and shales, siltstones, limestones and claystones of Pennsylvanian- to Devonian-age assigned to Unit F. The **Carbonate aquifer** includes the ridge-forming Silurian and Devonian dolomite of Unit E.

## 4. METHODS

This project focused on the collection of high-resolution helicopter-based geophysical data and the use of advanced modeling methods to create improved models of aquifer material distribution throughout most of Champaign County. This involved the collection, processing, and interpretation of approximately 3,145 km (1,954 miles) of helicopter time-domain electromagnetics (HTEM) data within the Champaign County boundaries. The HTEM data-collection boundaries are the Ford County/Champaign County border in the north, and between County Road 500 and County Road 400, north of the Village of Pesotum (Figure 5, green line) in the south. Along the 79 flight lines, more than 57,600 soundings were collected. Each sounding contains 40 resistivity values, resulting in more than 2.3 million individual resistivity values across the project area.

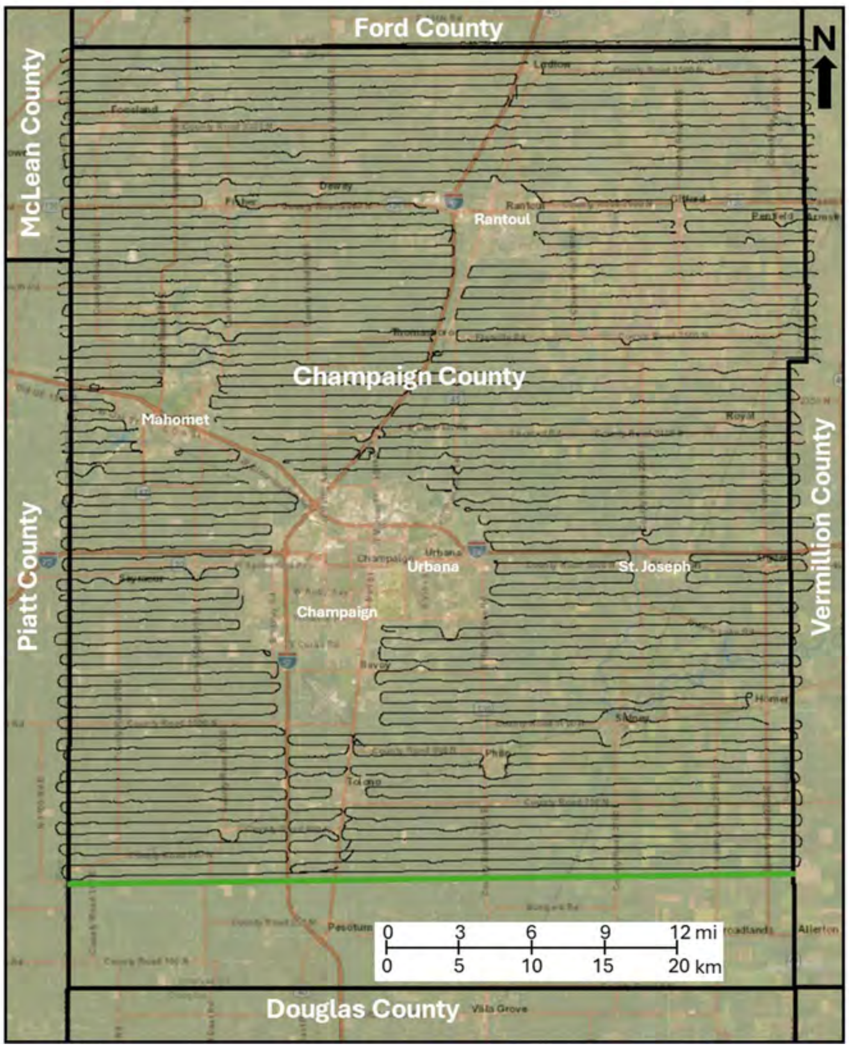


Figure 5. HTEM flight lines in Champaign County. Data were collected along 79 flight lines spaced at ~2,132 feet (650 m), from the Ford-Champaign County border to between County Road 500 and County Road 400, north of Pesotum. The green line shows HTEM data extent in southern Champaign County.

In addition to the HTEM data, funding was provided for the collection of other high-quality data : 1) ground-based geophysics data (i.e., seismic reflection profiles; 2) horizontal-vertical spectral ratio (HVSR) observation points; 3) electrical resistivity tomography (ERT) profiles); 4) drilling-based core sample descriptions; and 5) geophysical borehole data (Figure 6). Together, these data were used to develop the new, high-resolution 3-D model of aquifer and confining unit distribution (see Section 3.4 Hydrostratigraphic framework).

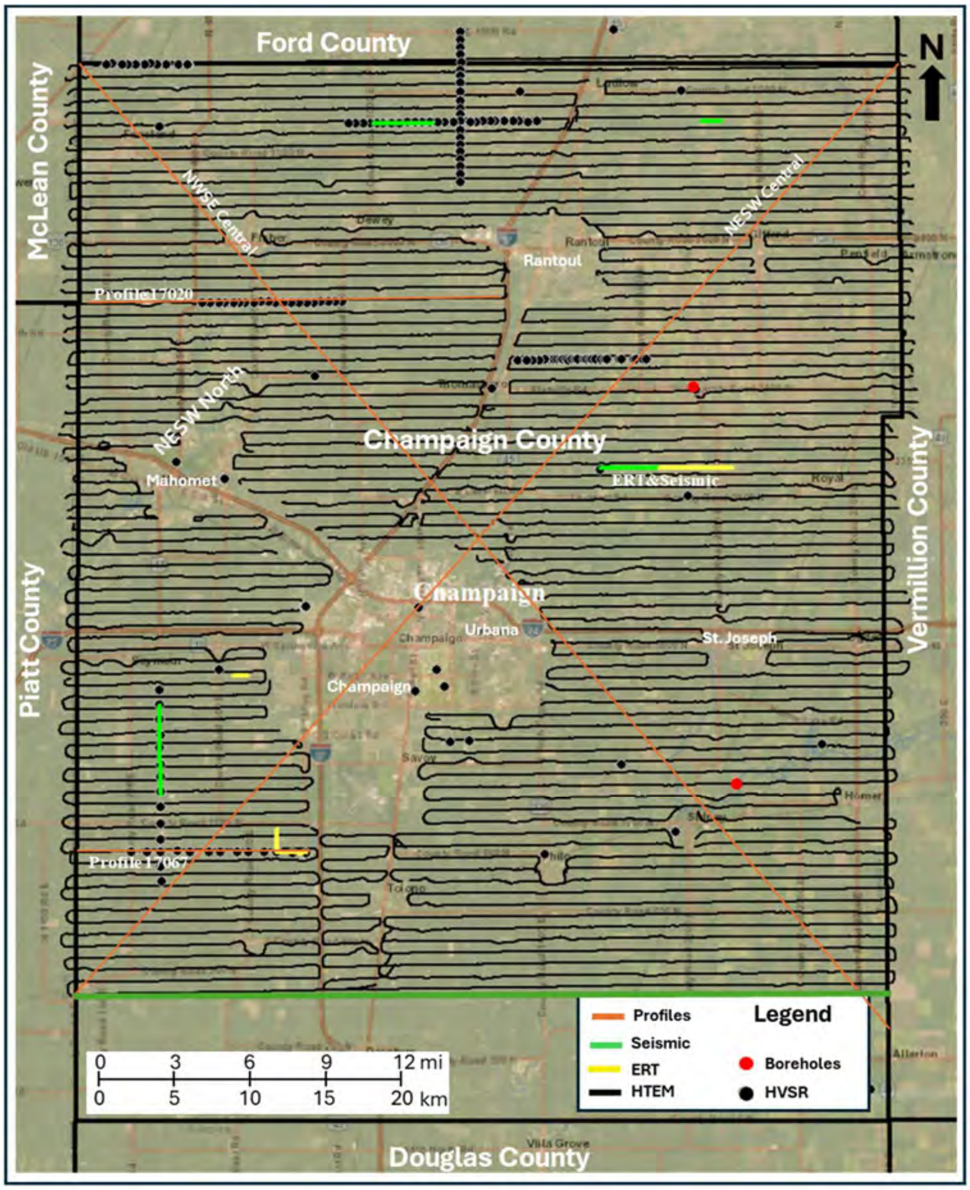


**Figure 6**. Additional ground-based geophysical data collection in Champaign County between 2023 and 2024. A total of 4.32 mi of ERT data (yellow lines) were collected along some HTEM lines. Seismic data (green lines, 9.72 miles) were co-located with both ERT, HTEM and HVSR (black dots) data. The orange lines present selected 2-D profiles of various data discussed below. The green line shows HTEM data extent in southern Champaign County.

All of the newly acquired and existing ground-based geophysical data and borehole information were used to improve the processing and interpretation of the HTEM data, and to provide information on the geometry of the Mahomet aquifer in the areas not accessible by the HTEM method (e.g., urban areas including the cities of Champaign and Urbana and the villages of Mahomet, Rantoul, etc.).

### 4.1 Field-Data Compilation and Collection

#### 4.1.1 Helicopter Time-Domian Electromagnetics (HTEM)

The airborne geophysical characterization in Champaign County involved the collection of HTEM data, which over the full 3,000+ km of flight line, produced millions of individual resistivity observations throughout the shallow subsurface. For this project, we contracted with SkyTEM Canada Inc., an international leader in the collection of high-resolution HTEM data. SkyTEM's acquisition system includes a dual-moment configuration that uses two concurrent EM pulses to image the subsurface at two different depth intervals (Sørensen and Auken 2004). The dual-moment HTEM system is designed to target both shallow and deeper subsurface deposits at a higher resolution than traditional HTEM systems. The use of dual-moment data for this project allows us to identify and interpret deposits throughout the upper 200–400 feet (60–120 m) below ground surface.

The HTEM (and ERT) methods measure variations in electrical resistivity in the subsurface. The measured resistivity (with units in ohm meters) is a bulk physical property of subsurface geologic materials that describe the resistance of an electrical current through the material (Figure 7). Electrical resistivity correlates well with several physical and chemical properties of these geological materials, including particle size, texture, bulk density, and ionic content (salinity) of pore water. Thus, two-dimensional (2-D) electrical resistivity measurements can be correlated with subsurface geologic material(s) (Figure 7). Different physical characteristics of specific rock types and variations in fluid saturation, porosity, clay mineral quantity (i.e., fraction) within a rock type all affect resistivity and are often investigated with the use or application of these geophysical methods.

The SkyTEM airborne HTEM system was mounted on a frame suspended about 40 m below the helicopter and was flown at a height of 36 m above land surface (Figure 8) or land-based objects (e.g., powerlines, trees). The helicopter was flown at an average of 60 miles/h (96.7 km/h), depending on the wind conditions during data collection. Observations were collected every ~33–98 feet (~10–30 m) along the flight transect. This spacing of data was selected because it is sufficient to characterize high-resolution horizontal variations in sediment types throughout the project area. The raw HTEM data received from SkyTEM were processed and inverted using Aarhus Workbench software. Data processing, inversion, and interpretation were completed by ISGS scientists.

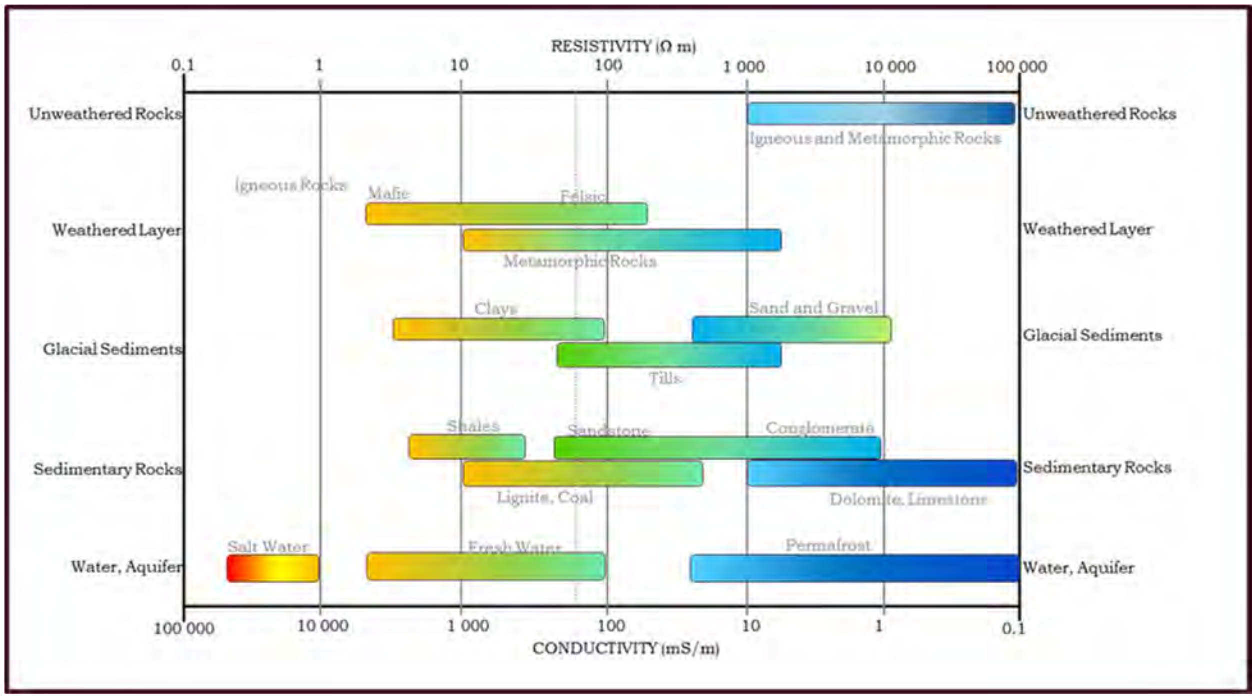


**Figure 7**. Resistivity range for various geologic materials (figure modified from Palacky 1987)

4.1.2 Electrical Resistivity Tomography (ERT)

As opposed to the helicopter-borne measurements in HTEM, resistivity measurements in ERT profiles are made by transmitting a direct current into the ground through a pair of electrodes (i.e., metal spikes) and measuring the resulting voltage using another pair of electrodes (Figure 8). The measured current and voltage are then converted into resistivity using a sequence of equations that consider the configuration of the electrodes on the ground. The resistivity distributions from ERT profiles, like HTEM resistivity distributions, are used to infer the characteristics of the geologic materials in the shallow subsurface.

For long 2-D profiles, a desired number of electrodes connected to a multi-core cable are laid out on the ground (Figure 8) and multiple measurements are carried out simultaneously and in rapid succession at different locations and depths along the profile to make a complete image of the subsurface. This is accomplished by switching electrodes which are taking measurements forward along a profile, and by increasing the separation between active electrodes to increase the depth of investigation. The depth of investigation of an ERT survey is the function of the spacing between electrodes. The aim of an overall process is to measure the resistivity of a dense network of points that can be used to create a (2-D) cross section of subsurface resistivity. ERT interpretations, supported by borehole data or alternate geophysical data, can accurately represent the geometry of the lithology and hydrology of the subsurface.

We acquired a total of 4.3 miles of ERT data on several roadways in Champaign County in the summer of 2023 (Figure 6 and Table 1). These profiles were collected to provide a secondary data source to the data acquired using the HTEM method. The goal was to use the ERT data to help validate the HTEM data. For all profiles collected in Champaign County, a dipole-dipole

ERT configuration was used. Profiles of continuous resistivity measurements were obtained every 5 meters, estimating resistivity values to depths of approximately 300 feet (100 m).

**Table 1.** ERT Survey Summary, Champaign County

| Profile | Length (km) | Length (miles) |
|---|---|---|
| 1500N | 0.8 | 0.50 |
| 2200N | 3.995 | 2.48 |
| 900N | 1.565 | 0.97 |
| 700E | 1.400 | 0.87 |
| Total | 6.960 | 4.32 |

### 4.1.3 Seismic Reflection Surveys

Seismic reflection methods have been used for mapping bedrock and overlying sediments for decades. Seismic reflection surveys measure the propagation of velocity and amplitude of seismic waves in the subsurface. There are two groups of seismic waves: 1) body waves which can travel through the subsurface and 2) surface waves that travel across the land surface. Body waves include compressional (P) and shear (S) waves. P-waves are the fastest type of seismic wave, and their movement is parallel to the direction of wave propagation. P-wave velocity depends on both the texture of the unconsolidated sediments or bedrock and the infills of pore space. Shear waves are slower than P-waves and travel perpendicular to the direction of wave propagation. S-wave velocity depends only on the properties of sediment or bedrock.

The strength of seismic reflection waves depends on the acoustic impedance contrast, which is fairly significant between the bedrock and the overlying sediments. The seismic reflection method also can differentiate between sediment having high clay and sand contents if the deposits they comprise attain a sufficient thickness, typically greater than 20 feet (6 m) thick. In addition, seismic reflection data can be collected more quickly than other geophysical methods, especially along easily accessible roads and trails. For example, data can be collected along one mile of road in one day using the Landstreamer seismic reflection acquisition system manufactured by the ISGS.

Seismic reflection surveys were conducted in the summer of 2024 by students and ISGS employees. A total of 15.66 kms (9.72 miles) of P-wave seismic reflection data were acquired (Table 2) as follows; Line 1 on County Road 300 E between County Road 1400 N and County Road 1100 N; Line 2 on County Road 2200 N between County Road 1800 E and County Road 2200 E; Line 3 on County Road 3400 N between County Road 1000 E and County Road 1200 E; and Line 4 on County Road 3400 N between County Road 2100 E and County Road 2200 E. The main objectives of these P-wave surveys were: 1) to map the bedrock topography in the project area and compare these results with what was obtained from the HTEM and other geophysical data; and 2) characterize the sediments overlying the bedrock.

**Table 2.** Seismic Survey Summary, Champaign County

| Line Number | Length (km) | Length (miles) |
|---|---|---|
| Line 1 – County Road 300 E | 4.85 | 3.01 |
| Line 2 – County Road 2200 N | 6.44 | 4.00 |
| Line 3 – County Road 3400 N | 3.29 | 2.04 |
| Line 4 – County Road 3400 N | 1.08 | 0.67 |
| Total | 15.66 | 9.72 |

#### 4.1.4 Horizontal-Vertical Spectral Ratio (HVSR)

The HVSR method is a 1-D seismic technique that makes use of naturally occurring ground vibrations (i.e., seismic noise) to delineate depth to different geological materials, especially depth to bedrock. These ground vibrations are produced by a combination of wind waves, long-period ocean waves, and locally, industry and vehicle traffic noise. Highly sensitive, 3-channel seismometers are used to record background vibrations in an area over a period of about 20 minutes (Figure 8). In order to capture the three-dimensional character of the vibrations, recordings are made in three directions: up/down, north/south, and east/west. Except for the occasional passing of a vehicle, the signals appear to be just random vibrations, white noise. By using advanced signal processing techniques, we can glean useful hydrogeologic information.

To extract the signal from the noise, the seismic recordings are first converted to spectra and then the amplitudes of the three components are compared, frequency-by-frequency. Over most of the spectrum the signal is noise; the amplitudes of the horizontal and vertical components are the same. But at a specific frequency there is resonance; the amplitude of the horizontal component becomes greater than the vertical component. This resonant peak is a proxy for depth to a change in the subsurface geological material. Due to their differing physical properties, the most abrupt changes in seismic character in Illinois are often at the interface between bedrock and the overlying unconsolidated material, enabling the finding of depth to bedrock and, with some awareness of the regional geology, a basic understanding of lithology.

A total of 180 HVSR points were collected in Champaign County between the summers of 2023 and 2025. These data were collected to equally cover the HTEM, ERT, and seismic study areas, including areas not covered by other geophysical data.

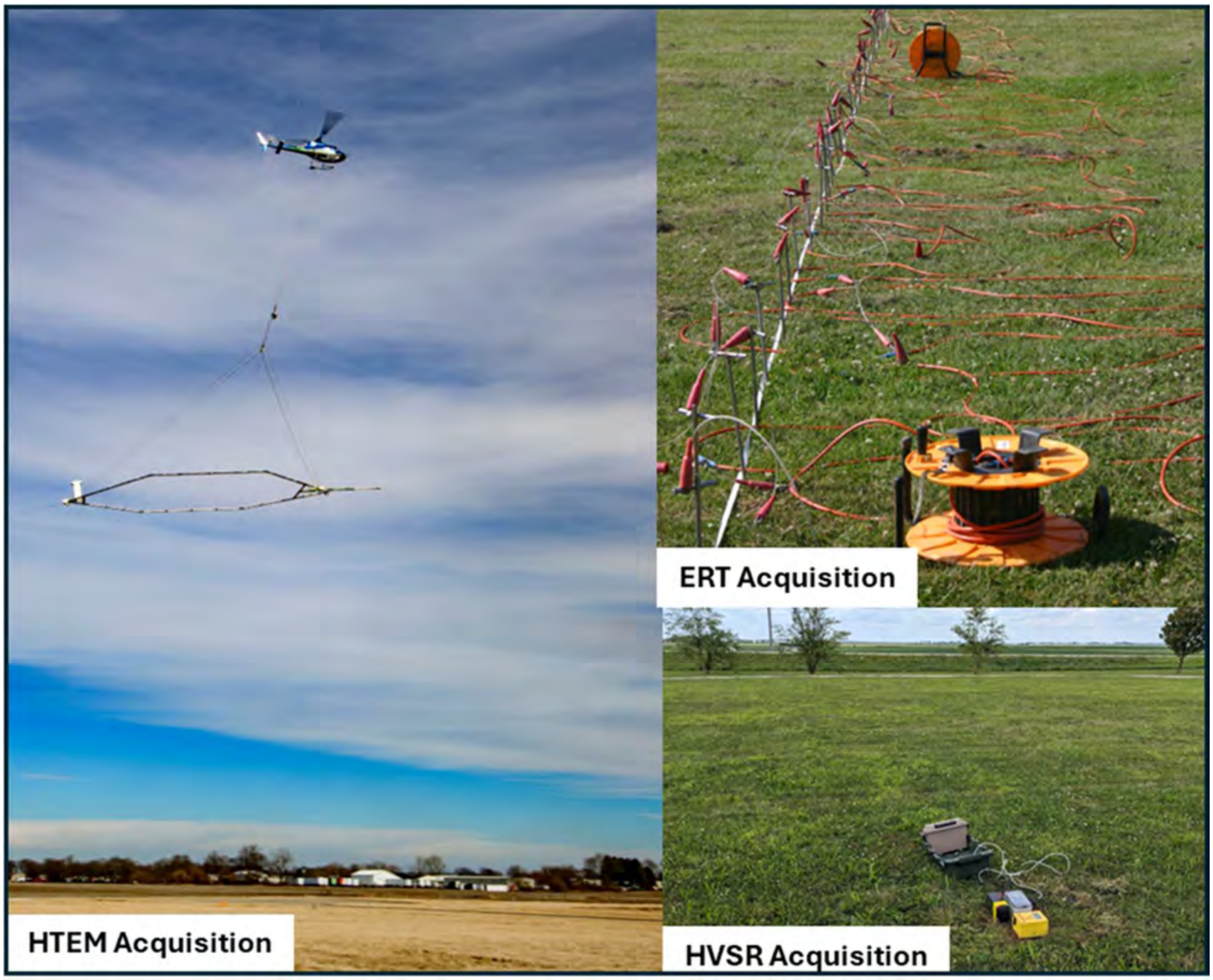


**Figure 8**. Instrumentation used in acquiring new HTEM, ERT and HVSR data in Champaign County.

### 4.1.5 Drilling

Boreholes have been used for decades as the most valuable source of information during geological mapping. Analysis and interpretation of the information obtained from boreholes can reveal mappable relationships between geologic units in the subsurface. While the most accurate source of information, boreholes are limited in their value because they only observe a discrete volume of the subsurface, effectively providing a vertical (1-D) description of geological information at the borehole location. Depending on the size of the project area, several boreholes, drilled at strategic locations, can be used for geological mapping and/or ground-truthing of other data types. For this project, two boreholes were drilled near the unincorporated area of Flatville and Town of Sydney, Illinois (Figure 6), to ground-truth the HTEM and other geophysical data. The Flatville borehole was selected to ground-truth HTEM data located within the Mahomet Bedrock Valley, while the Sydney location was selected to ground-truth data outside the bedrock valley. Boreholes extending from the land surface to bedrock (77.72 m in Flatville and 60.35 m in Sydney) were drilled to collect geological cores and/or samples (Figure 9) of glacial and nonglacial sediment and bedrock. The cores and samples were used to examine the physical characteristics of the drilled geological material. Table 3 and Table 4 present geological information from drilled cores and/or samples from Flatville and Sydney, respectively.

Together with core sample collection, downhole geophysical measurements were acquired to support the geological description of core samples and also to support other surface geophysical methods. One of the most common and reliable downhole geophysical logging methods used, particularly within unconsolidated sediments, is natural gamma. Natural gamma logging is a passive method that detects variations in energy emitted from naturally occurring radioactive isotopes (radioisotopes) present within the earth surrounding the borehole. Most natural earth radiation is generated from isotopes of Potassium-40 ($^{40}K$), and the natural decay series of Uranium-238 ($^{238}U$) and Thorium-232 ($^{232}Th$) (Keys 1990; Telford et al. 1990; Kearey and Brooks 1991; Rider 1996). Measurements are collected using a thallium activated sodium-iodide scintillation gamma ray detector located in the bottom half of a probe, which when struck by a gamma ray emits a pulse of light. The light emissions are amplified by a photon multiplier and outputted as a current pulse that is transmitted through a cable to the receiver. The pulses are counted and displayed as counts per second (CPS).

In Illinois, these radioisotopes are more abundant in clay-rich sediments and bedrock (shale and claystone), and less concentrated in well-sorted sand and gravel or carbonate rich materials. In glacial sediments, variability in gamma response is related principally to the matrix clay content and locally to the presence of concentrations of granitic, gneissic, and shale rocks, which are a source of K, U, and Th (Pehme 1984). Consequently, a low natural gamma response generally indicates zones of porous and permeable sand and gravel in unconsolidated sediments, and crystalline limestone and dolomite bedrock.

**Table 3**. Geologic log from a borehole drilled in Flatville, Illinois *(Drilling began July 17th, 2023, on the site located at Latitude: 40.23928°; Longitude: -88.061668°)*

| Depth Top (m) | Depth Bottom (m) | Depth Top (ft) | Depth Bottom (ft) | Description |
|---|---|---|---|---|
| 0 | 3.05 | 0 | 10.00 | Silt and clay (with sand lenses) |
| 3.05 | 9.14 | 10.00 | 29.99 | Diamicton (silt clay loam) |
| 9.14 | 18.29 | 29.99 | 60.00 | Sand and diamicton (interbedded) |
| 18.29 | 33.53 | 60.00 | 110.00 | Sand (fine sand) |
| 33.53 | 42.67 | 110.00 | 139.99 | Diamicton (silt clay loam) |
| 42.67 | 76.20 | 139.99 | 250.00 | Sand and Gravel (coarse) |
| 76.20 | 77.72 | 250.00 | 254.99 | Dolomite/Limestone |

**Table 4.** Geologic log from a borehole drilled in Sydney, Illinois *(Drilling began on October 16th, 2023, on the site located at Latitude: 40.045279°; Longitude: -88.038239°)*

| Depth Top (m) | Depth Bottom (m) | Depth Top (ft) | Depth Bottom (ft) | Description |
|---|---|---|---|---|
| 0 | 1.52 | 0 | 4.99 | Silt and sand |
| 1.52 | 13.72 | 4.99 | 45.01 | Till |
| 13.72 | 15.24 | 45.01 | 50.00 | Paleosol |
| 15.24 | 16.76 | 50.00 | 54.99 | Sand |
| 16.76 | 18.29 | 54.99 | 60.00 | Gravel |
| 18.29 | 21.34 | 60.00 | 70.01 | Sand |
| 21.34 | 33.53 | 70.01 | 110.01 | Till |
| 33.59 | 51.82 | 110.01 | 170.01 | Silt and sand |
| 51.82 | 56.39 | 170.01 | 185.01 | Shale (weathered bedrock) |
| 56.39 | 60.35 | 185.01 | 197.99 | Sandstone/siltstone |


**Figure 9.** Photos of drilling and core/sample analysis in Sydney, Illinois. Core samples were collected for analysis from surface to a depth of 77.72 m in Flatville and 60.35 m in Sydney.

## 4.2 Geological Modeling

### 4.2.1 HTEM Data Interpretation Process

The process for HTEM data interpretation was based on a new method developed specifically for this project, the Material-Type Characterization (MTC) method (Keefer et al., in preparation). This MTC method involves the combination of multiple sources of geologic knowledge with the observed resistivity values to obtain high-resolution interpretations of material-type distributions throughout the project area. The MTC goal is twofold, to enable a high-resolution interpretation of the HTEM data that captures what is known about the geology, and to enable the creation of multiple, geologically plausible interpretations that are anchored in the data and knowledge, and that express variations captured in conceptual models of material type distribution.

The MTC process starts with the interpolation of the more than 2,300,000 inverted HTEM resistivity values (Figure 10) into a single 3-D cube of resistivity values (Figure 11). The HTEM data distribution is so dense that 3-D interpolation can be configured to create a high-resolution 3-D grid of resistivity values that is anchored to the observations. The cell size chosen for the 3-D models in this project is 100 m × 100 m × 2 m (100 m cell size in the horizontal or N–S and E–W directions, and 2 m cell size in the vertical direction). The full 3-D grid used for this project is 468 cells wide (E–W direction), 522 cells long (N–S direction), and 130 cells high (vertical direction).

Once the resistivity data is interpolated to a 3-D grid, the distribution of resistivity values within the grid is analyzed. The grid is sliced horizontally, from bottom to the top, and the occurrence and changes in resistivity values are noted and summarized. This resistivity summary is further analyzed considering our current knowledge of glacial deposits across Illinois, based on decades of research at the Illinois State Geological Survey (Hansel and Johnson 1996; Grimley and Phillips 2011; Stumpf et. al., in review). This analysis and comparison to the regional geologic history allows for the identification and mapping of electro-stratigraphic units within the 3-D resistivity cube (Figure 11). These units can be based primarily on changes in resistivity patterns but also on an awareness of regional changes in material properties, reflecting patterns in the resistivity values that are compatible with sediment patterns expected within the project area.

In the current project area, six electro-stratigraphic units were identified, Units A–F. Because these units are based on patterns in HTEM data, they do not correlate perfectly with the formal lithostratigraphic units in Illinois (Stumpf et. al., in review; Hansel and Johnson, 1996). Generally, Unit A is defined by relatively low resistivity values; most values are between 30 and 55 Ohm-m. Deposits in Unit A are of the Wisconsin Episode (Wedron and Mason Groups) and primarily contain fine to loamy textured diamictons, and poorly to moderately sorted sands. Unit B is defined by moderate resistivity values; most resistivity values are between 45 and 75 Ohm-m. Deposits in Unit B are primarily of the late Illinoian Episode (Pearl and Glasford Formations), with some Wisconsin (Tiskilwa Formation and Ashmore Tongue) and early Illinoian sediments (Glasford and Pearl Formations) expected locally. Sediments in Unit B primarily contain a mixture of moderately to poorly sorted sands, with less frequent occurrences of loamy diamicton. Unit C is defined by relatively low resistivity values; most values are between 30 and 60 Ohm-m. Deposits in Unit C are generally of the late pre-Illinois Episode (Banner Formation), with some early Illinois Episode (early Glasford and Pearl Formations) expected locally. Sediments in Unit C primarily contain mixtures of loamy diamictons with all levels of sorted sands. Unit D is defined by relatively high resistivity values; most values are between 55 and 125 Ohm-m. Deposits in Unit D are primarily of the early to middle pre-Illinois Episode (Banner Formation) with some late Banner expected locally. Unit E is defined by low resistivity values; most values are between 5 and 40 Ohm-m. Deposits in Unit E are primarily shales and sandstones of the Mississippian and Pennsylvanian Period, with some pre-Illinois Episode (early Banner Formation) fine-grained deposits expected at the top surface; these fine-grained Banner sediments are expected primarily in the southeastern quarter of the project area. Unit F is defined primarily by high to very high resistivity values; most values are between 50 and 250 Ohm-m, with some areas of lower and much higher resistivity locally. Deposits in Unit F are primarily carbonates of the Silurian and Devonian Period, with potentially some Mississippian and Pennsylvanian shales, and some pre-Illinois (early Banner sediments) expected locally.

Once these stratigraphic units are defined, their distribution, with knowledge of sediment and rock types in these zones, are used to model the resistivity-to-material type relationship. This relationship defines the different material types that could be associated with any observed resistivity value. As noted above (Figure 7), there are several different geologic material types that correspond to most resistivity values. As also noted above (Section 4), the electrical resistivity of earth materials is dependent on several properties: 1) porosity; 2) particle size distribution; and 3) specific conductance of the fluid in the pore spaces. Following research from Denmark (Foged et al. 2014), we determined that for our project, the fraction of the geologic material that is composed of clay minerals (i.e., clay mineral fraction) could be used as the primary predictor of material types for each resistivity measurement. To improve the reliability of each material type-resistivity pairing, we relied on the thousands of particle size analyses that have been conducted at the ISGS over the years and that have been used to identify and characterize the formal geologic units throughout the state (Hansel and Johnson 1996; Grimley and Phillips 2011; Stumpf et.al., in review).

For this project, the primary goal was the delineation of deposits classified according to hydrostratigraphic units (e.g., aquifers and confining units). This classification only required the identification of general hydrologic material types. The hydrologic material type classifications for this project include a sandy aquifer, carbonate aquifer, clayey confining unit, leaky clayey confining unit, and shale confining unit. However, the detail in historical geologic knowledge allowed us to identify lithologic material types, which are defined using more general sedimentologic terms. There are several lithologic material types that can be grouped into hydrologic material types, providing more insight on the high-resolution distribution of these more detailed characteristics. While not directly relevant to the County Board and their use of this information, these lithologic material types are expected to be particularly relevant to groundwater modelers or hydrologists interested in gaining the more detailed insights provided by the HTEM data. The lithologic material classification for this project contains 20 units: clay, clayey sediments, silt and clay sediments, silty sediments, silt, fine diamicton, loamy diamicton, coarse diamicton, very poorly sorted sands, poorly sorted sands, moderately sorted sands, well sorted sands, very well sorted sands, extremely well sorted sands, partially cemented sands, cemented sands, shale, weathered shale, carbonate, and weathered carbonate. The resulting relationship between resistivity, lithologic material type, and hydrologic material type is presented in Table 5.

**Table 5.** Resistivity – Material Type Relationships

| Resistivity Range (ohm m) | Lithologic Material Type | Hydrologic Material Type |
|---|---|---|
| 1 - 15 | Shale | Shale Confining Unit |
| 15 - 20 | Clay; Shale; Weathered Shale | Clayey Confining Unit; Shale Confining Unit |
| 20 - 35 | Clay; Clayey Sediments; Silt and Clay Sediments; Fine Diamicton; Loamy Diamicton; Weathered Shale | Clayey Confining Unit; Shale Confining Unit |
| 35 - 45 | Silt and Clay Sediments; Fine Diamicton; Loamy Diamicton; Very Poorly Sorted Sands; Weathered Shale | Clayey Confining Unit; Leaky Clayey Confining Unit; Shale Confining Unit |
| 45 - 55 | Silty Sediments; Loamy Diamicton; Poorly Sorted Sands; Coarse Diamicton; Weathered Shale | Clayey Confining Unit; Leaky Clayey Confining Unit; Shale Confining Unit |
| 55 - 120 | Silty Sediments; Silt; Loamy Diamicton; Coarse Diamicton; Moderately Sorted Sands; Well Sorted Sands; Weathered Carbonate | Clayey Confining Unit; Leaky Clayey Confining Unit;<br>Sandy Aquifer; Carbonate Aquifer |
| 120 - 600 | Silt; Very Well Sorted Sands; Extremely Well Sorted Sands; Partially Cemented Sands; Cemented Sands; Weathered Carbonate; Carbonate | Clayey Confining Unit; Sandy Aquifer;<br>Carbonate Aquifer |
| >600 | Cemented Sands; Carbonate | Carbonate Aquifer |

Table 5 clearly shows the ambiguity in interpreting material type from almost any resistivity value. For example, a resistivity value of 100 Ohm-m could be due to the occurrence of 7 different lithologic material types or 4 different hydrologic material types. The MTC method includes a process for reducing and managing the ambiguities in these relationships, which results in an improvement in the utility of material-type interpretations from the HTEM data.

Traditional geologic modeling and mapping efforts reflect a geologist's most likely, or preferred interpretation of material type distributions. Largely because the sparse datasets used in traditional mapping led to an extremely high level of uncertainty, it is both difficult to characterize this uncertainty, and difficult to generate alternative interpretations that honor the data. The availability of uncertainty characterizations, particularly in the form of alternative interpretations, can be helpful to groundwater modelers, hydrologists, and decision makers because it allows them to consider alternative geological framework models and test the impact of differences to their targeted outcomes. This type of capability can be valuable for improving risk assessments for difficult water resources or planning decisions. The MTC method provides the ability to generate multiple interpretations of the material type distributions. The large HTEM dataset provides grounding for these alternate interpretations, dramatically improving their reliability, to a degree that is not available with traditional modeling and mapping of datasets.

The main tool we used for managing the ambiguities within the resistivity-to-material type relationship is a geologic conceptual model, specifically conceptual models of lithologic material type occurrence within each of the stratigraphic units. Each conceptual model is based on the historical regional knowledge of material distribution within that depth range, and of a generalization of patterns of aquifer occurrence observed within borehole-based data.

For this project, we identified three conceptual models for each of the 6 electro-stratigraphic units. The first conceptual model, and the one we use exclusively within this report, is the Preferred conceptual model. It defines what the geologists interpreted as the most likely, or preferred, proportion of the 20 lithologic material types for each electro-stratigraphic unit. This conceptual model was based on a review of the resistivity distributions in each unit, the various existing publications on the geology in the region, the extensive records of particle size distribution across Champaign County, the availability of geophysical borehole logs of various kind (i.e., natural gamma logs, electrical resistivity logs), available core sample descriptive logs, and available water well drillers logs.

As an example of how these conceptual models were used, the Preferred conceptual model for Unit A suggested that for resistivity values of 55–75 Ohm-m, deposits are interpreted as poorly sorted sand 12% of the time, loamy diamicton 70% of the time, and coarse diamicton 16% of the time. The same resistivity range in Unit B would be interpreted as moderately sorted sand 60% of the time and loamy diamicton the remaining 40% of the time. In Unit D this range of resistivity values would be interpreted as well sorted sand 30% of the time, loamy diamicton 30% of the time, and moderately sorted sand 40% of the time. This approach of constraining material type occurrence for each resistivity category was carried out for each of the 6 electro-stratigraphic units for each conceptual model.

In choosing how to model alternative material type distributions, it is helpful to consider the needs of specific stakeholders. Experts in groundwater resource protection and management are a prominent stakeholder group for the geological model of the project area. To create alternative interpretations that support the needs of this group, we recognized that groundwater protection and management decisions are most affected by the quantity and distribution of sand aquifers. We determined that it would be helpful for this stakeholder group if we created two additional conceptual models to explore alternative interpretations in the amount and distribution of sand—one could explore significantly higher likelihood of sand occurrence and one could explore significantly lower likelihood of sand. These conceptual models, called HiFreqSand and LoFreqSand respectively, were created to contain geologically plausible changes to the proportions of the 20 material types within each electro-stratigraphic unit. The resulting 3-D interpretations from these alternate conceptual models are not presented in this report to avoid complicating discussions with general, non-technical audiences about the distribution and character of aquifers. The creation of different interpretations, based on different conceptual models, is designed to be of particular use to technical stakeholders who understand and regularly work with uncertainty in geologic material distributions.

The ability to model high-resolution variations in large numbers of material types is fundamental to providing high-fidelity geologic models that better support groundwater management and protection needs in high-use and high-vulnerability situations. However, the main goal of this project was the interpretation of the 3-D distribution of hydrostratigraphic units. In developing the process for converting hydrologic material type to hydrostratigraphic units, we determined that a simplified hydrologic material type classification made the process easier to implement. This simplified classification has only three categories: aquifer, leaky confining unit, and confining unit. The 3-D model of hydrostratigraphic units applies to this 3-category hydrologic material type interpretation with the distribution of the 6 electro-stratigraphic units to delineate the distribution of ten hydrostratigraphic units (Table 6). This 3-D model of hydrostratigraphic unit distributions is the final product and end goal of this project.

**Table 6**. Hydrostratigraphic units, their constituent hydrologic material types, and corresponding stratigraphic units.

| Hydrostratigraphic Unit Name | Constituent Hydrologic Material Type | Corresponding Electro-Stratigraphic Units |
|---|---|---|
| Shallow confining unit | Confining Unit, Leaky Confining Unit | Unit A |
| Shallow aquifer | Aquifer | Unit A |
| Upper middle confining unit | Confining Unit, Leaky Confining Unit | Unit B, Unit C |
| Upper middle aquifer | Aquifer | Unit B, Unit C |
| Lower middle confining unit | Confining Unit, Leaky Confining Unit | Unit B, Unit C, Unit D |
| Lower middle aquifer | Aquifer | Unit B, Unit C, Unit D |
| Mahomet confining unit | Confining Unit, Leaky Confining Unit | Unit C, Unit D |
| Mahomet aquifer | Aquifer | Unit D |
| Carbonate confining unit | Confining Unit, Leaky Confining Unit | Unit D, Unit E |
| Carbonate aquifer | Aquifer, Leaky Confining Unit | Unit D, Unit F |

To ensure the 3-D grids of interpreted hydrologic material type and hydrostratigraphic unit distributions were accurate, we conducted several evaluation and validation efforts. These involved graphical display and subsequent analysis of the interpretations to ensure the proportions of aquifers and confining units, and the spatial distribution of these units met with our expectations based on Stumpf's (in review) material type patterns, and general patterns of hydrologic material type from borehole-based observations. Specifically, we created and evaluated a set of vertical cross sections (profiles) and elevation-based map views (horizontal slices) through the 3-D grid. The hydrologic material type distributions were analyzed first. Whenever the distribution did not fit either Stumpf's predicted patterns or the borehole-based observational data, the conceptual models were adjusted until the interpreted distribution met, and validated, these expectations. This same type of graphically based evaluation was conducted with the hydrostratigraphic unit distributions; discrepancies between expectations and interpretations were addressed by either changing the criteria for defining the different hydrostratigraphic units, or by adjusting the computer program that we used to make the assignments. This process was repeated until the distribution of hydrostratigraphic units, as observed in profiles and horizontal slices, was consistent with our definitions of these units.

### 4.3 Limitations, Uncertainty and Data Resolution

As we have noted, traditional geologic mapping and modeling studies use much smaller datasets than are available with HTEM surveys. In a county with the size of Champaign, traditional mapping projects would collect a few dozen core sample sets, producing detailed descriptive logs of variations in material type. Interpretations of geologic unit distributions, the character or architecture of those units, and the resolution of the interpretations of these distributions are influenced heavily by the sparsity of the underlying data. In these studies, geologic units are often generalized, ignoring internal variations in material type and properties, to reliably identify the units in the sparse data and to produce unit boundaries that are sufficiently reliable for the data distribution while still addressing stakeholder needs. While there have been incremental improvements in data quality over the past 70+ years, these innovations have not resulted in large increases in the number of observations collected for most mapping or modeling efforts. This absence in dramatic change in data quantity has resulted in the development of stable and standard approaches to data analysis, interpretation, and model creation. The uncertainties of these interpretations are large and rarely quantified, as the sparsity and irregularity of data make the uncertainties difficult to estimate. The application of maps and models, made from these standard methods to a range of problems and decision-making situations, has demonstrated that the reliability of these models is typically sufficient for their purpose. University research into the value of high-resolution, high-reliability geologic models, however, suggests that improved resolution and reliability in model results would provide significant value to a range of stakeholder applications.

Innovations in helicopter-based TEM data collection, processing, and interpretation were developed in the early 2000s, and provided a significant increase in data quantity to geologic modeling studies focused on the upper 1000 feet (305 m) from land surface. This jump in data quantity resulted in a sea-change of capabilities for subsurface geologic modeling, particularly dramatic improvements in the spatial resolution and accuracy of material type interpretations. This Champaign County project has collected 57,600 1-D resistivity soundings (similar in geometry to core sample sets), which have provided more than 2.3 million individual resistivity values. The value of these datasets has resulted in regional HTEM datasets being collected across the globe. Discussions with researchers and HTEM contractors suggest these data are being used primarily to help characterize aquifer systems under increasing stresses of demand with population growth and climate-induced changes in recharge. The transformative increase in data, with HTEM surveys, allows for equally significant changes in how the subsurface is described and understood. The MTC interpretation method, developed for this project, is one example of how these data are providing transformative capabilities for understanding the subsurface.

# 5. RESULTS AND INTERPRETATIONS

## 5.1 Geophysical Results

All 2-D resistivity inversion results from the HTEM survey resulted in a similar six-layer structure divided into unconsolidated quaternary deposit layers and bedrock layers. So, for the sake of brevity, we primarily focus on just a few figures (and profiles) for illustration (although integrated results from the inversion of all lines are presented later). Figure 10 illustrates 2-D resistivity results from all of the profiles (flight lines) from the HTEM survey, while Figure 11 illustrates the interpolated 3-D cube of the resistivity results from Figure 10. The results in both figures are presented in the form of resistivity in Ohm m. All images show in high resolution six-layers consistent with high resistivity layers (red and pink) indicative of course-grained material (sand and gravel) and/or carbonates (dolomite and limestone). The low resistivity layers (blue and green) are indicative of fine-grained material, such as clay and shale.

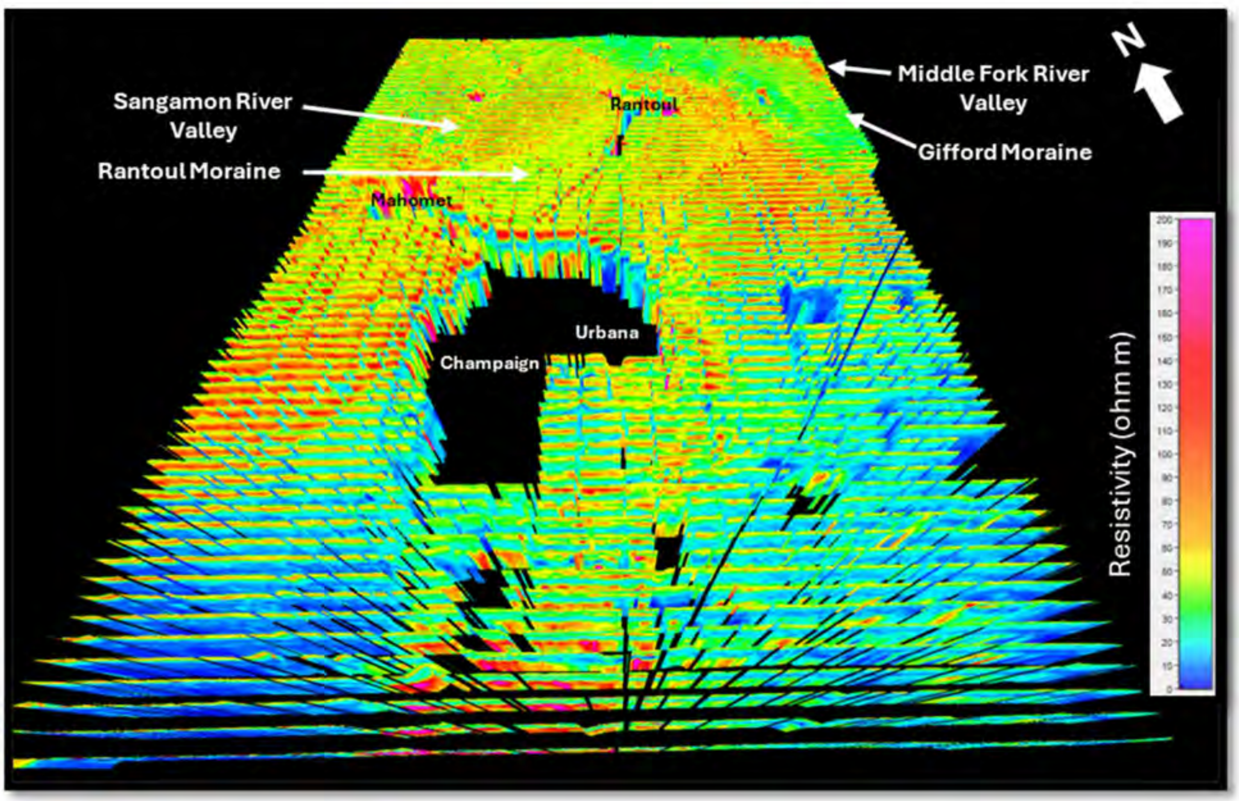


**Figure 10.** Perspective view of the resistivity results along the HTEM survey lines in Champaign County. The variations in resistivity values shown can be correlated to the different geologic materials found in the subsurface. High resistivity values (red and pink colors) represent coarse-grained materials (e.g., sand and gravel) and/or carbonate bedrock (e.g., limestone and dolomite), whereas the lowest resistivity values (bluish colors), denote the presence of fine-grained materials (e.g., glacial clays and shale bedrock).

While the north side of Champaign County shows dominant high resistivity layers for both shallow and deeper sediments (Figures 10 and 11), the southern side is dominated by low resistivity sediments, especially in the deeper layers, with some medium resistivity layers in the shallow sediments (Figure 10). Such contrast is expected, given the expected contrast in distribution of the bedrock materials, and sand and gravel materials. The northern side of Champaign County is known to be dominated by very resistive dolomitic bedrock (Figure 11) overlaid by resistive sand and gravel of the Mahomet aquifer and other shallow aquifers. Due to similarity in resistivity between sand and gravel, and dolomite, it is difficult to visually pick a contact between these two layers in Figure 11. In contrast, the southern side of the county is dominated by low resistivity shale bedrock (Figure 10) and the dolomitic Pesotum Anticline, in the center of the county.

Another prominent feature that we are able to map at high resolution with the contrast in resistivity distribution, is the low to medium resistivity Gifford Moraine in the northeast corner of the county (Figure 4, Figures 10 and 11). The Gifford Moraine is associated with glacial deposits, primarily made up of clay materials. South of the town of Rantoul (Figures 10 and 11) we see the low resistivity Rantoul Moraine, made up of clay material (Figure 4 and Figures 11). On the topmost corner of Champaign County, northeast of the Gifford Moraine, we see a resistive feature trending southeast; this feature is interpreted to be the Middle Fork River filled with sandy materials. It is worth noting that the feature we see in the middle of Figure 11 (resistive bedrock) and the shallow conductive (less resistive) layer on the western side of Figures 11 and in Figure 10 are major features that are continuous for most of the county.

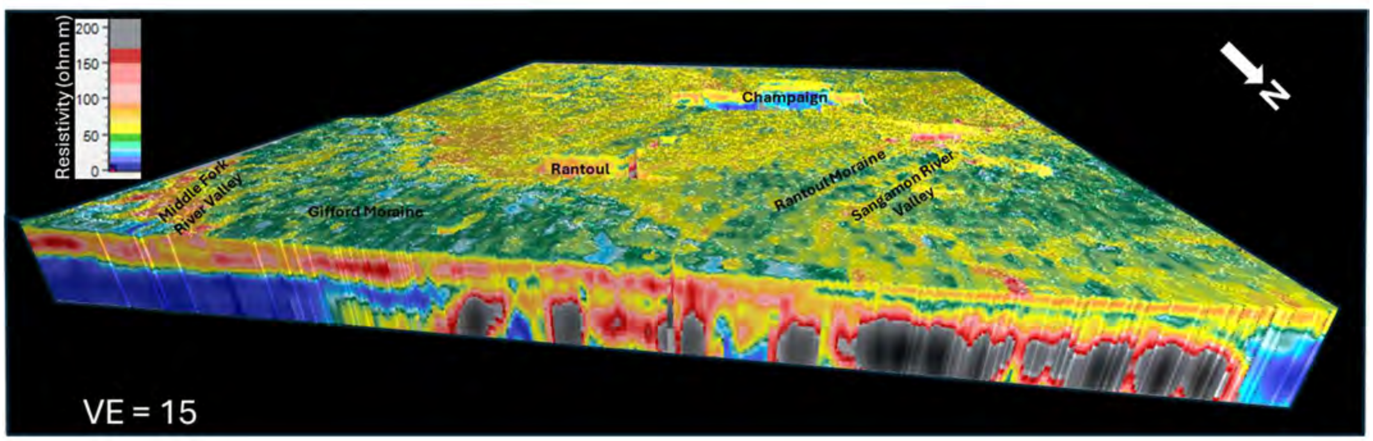


**Figure 11**. Perspective view towards the south of the 3-D model of the interpolated HTEM resistivity values created from data along the survey lines shown in Figure 10. The highest resistivity values (red and gray colors) represent coarse-grained materials (e.g., sand and gravel) and/or carbonate bedrock (e.g., limestone and dolomite), whereas the lowest resistivity values (bluish colors) denote fine-grained materials (e.g., glacial clays and shale).

Considerable variation in distribution of resistivity of mappable features, is captured when moving through different elevations. The major feature of interest in this project is the sand and gravel material, i.e., aquifer materials. Figure 12 shows the distribution of resistivity at 170 m (560 feet) elevation. The estimated distribution of sand and gravel material (high resistivity) is predominant in the middle of the project area, trending northeast–southwest, with higher resistivity observed in the middle of the project area and northeast corner of the county. The higher resistivity sections in this area can be interpreted as areas dominated by coarser grained materials, which are thick aquifer materials. There is a considerable decrease in resistivity (i.e., change in distribution of geological materials) as you move northwest and southeast of the project area. This low resistivity layer (blue) is interpreted as a shale bedrock layer surrounding the resistive unconsolidated aquifer materials. Overlying the shale bedrock layer on northwest and southwest of the project area are channel like features of high resistivity. The channel like features enclosed in the dashed black circles in Figure 12 are interpreted as possible sand-filled buried channels connected to the MBV. The possible buried channels are mapped in high resolution on high bedrock elevation in areas outside the MBV, suggesting a possible feeding into the MBV.

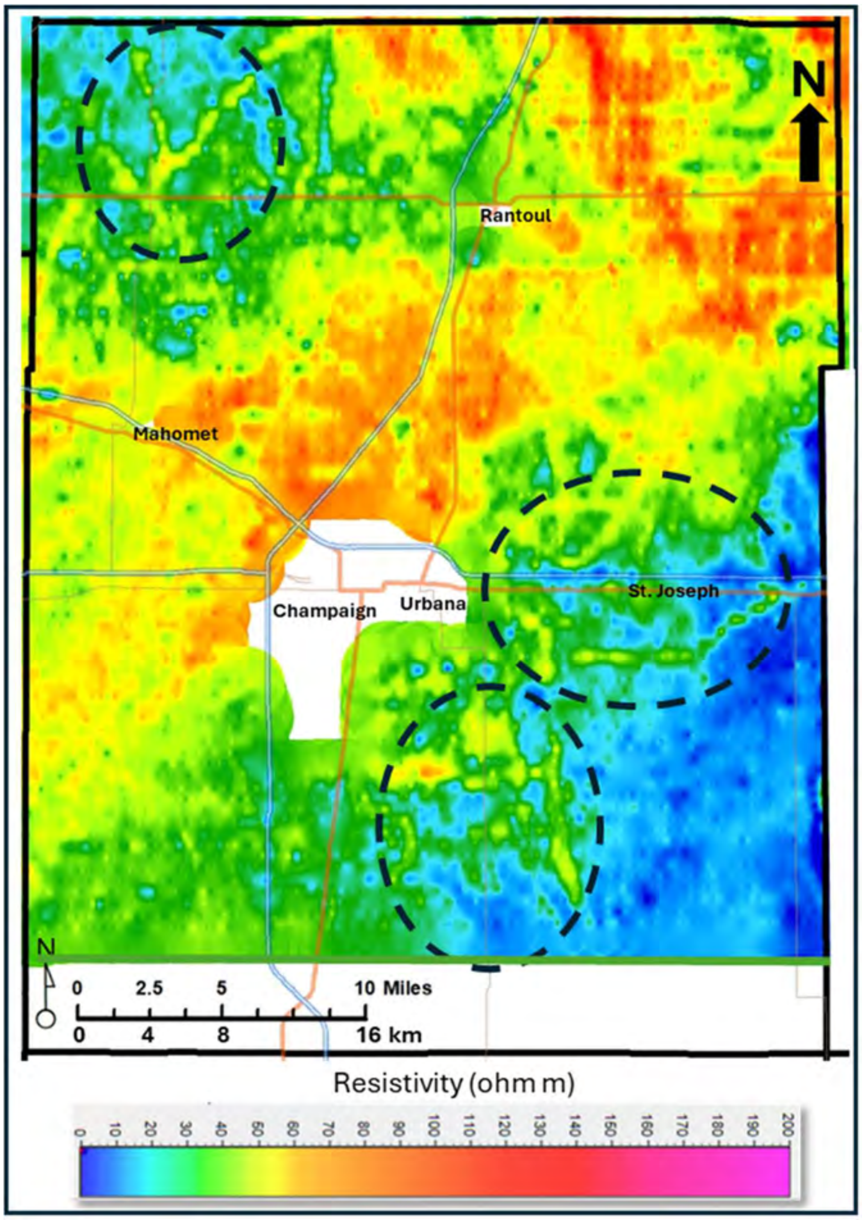


**Figure 12**: Horizontal slice through the 3-D HTEM resistivity model at 170 m (560 feet) elevation. The dashed black circles delineate possible areas with buried channels connected to the MBV. The highest resistivity

values (red and dark orange colors) represent coarse-grained materials (e.g., sand and gravel) and/or carbonate bedrock (e.g., limestone and dolomite), whereas the lowest resistivity values (bluish colors) represent fine-grained materials (e.g., glacial clays and shale). The green line shows HTEM data extent in southern Champaign County.

The 2-D inversion results of two long profiles across the project area, NWSE Central and NESW Central (Figure 6) presented in Figure 13 show the six geological layers varying in resistivity values with depth. As expected, the deeper bedrock Units E and F show the high resistivity values corresponding to the dolomite bedrock layer and low resistivity values corresponding to the shale bedrock layer, respectively. A sharp contrast in resistivity is observed between the shale bedrock (Unit F) and the overlaying high resistivity Unit D (e.g., at 25,000–40,000 m on NWSE Central and 0–60, 000 m NESW Central). This contact is mapped in high resolution due to the high contrast in resistivity values, and its elevation can be interpreted as the bedrock topography (top of bedrock) and bottom of the MBV. Conversely, the contact between Units D (sand and gravel) and E (dolomite) is very difficult to define due to both having high resistivity values, for example at 10,000–25,000 m on Figure 12 NWSE Central. Here we use general knowledge of the project area, and borehole information to define the contact (bedrock topography) between dolomite, and sand and gravel. Note, data gaps along the profiles (Figure 13) are areas with removed bad data (along powerlines) and/or areas without data (e.g., Fisher, Champaign, Urbana, and Gifford).

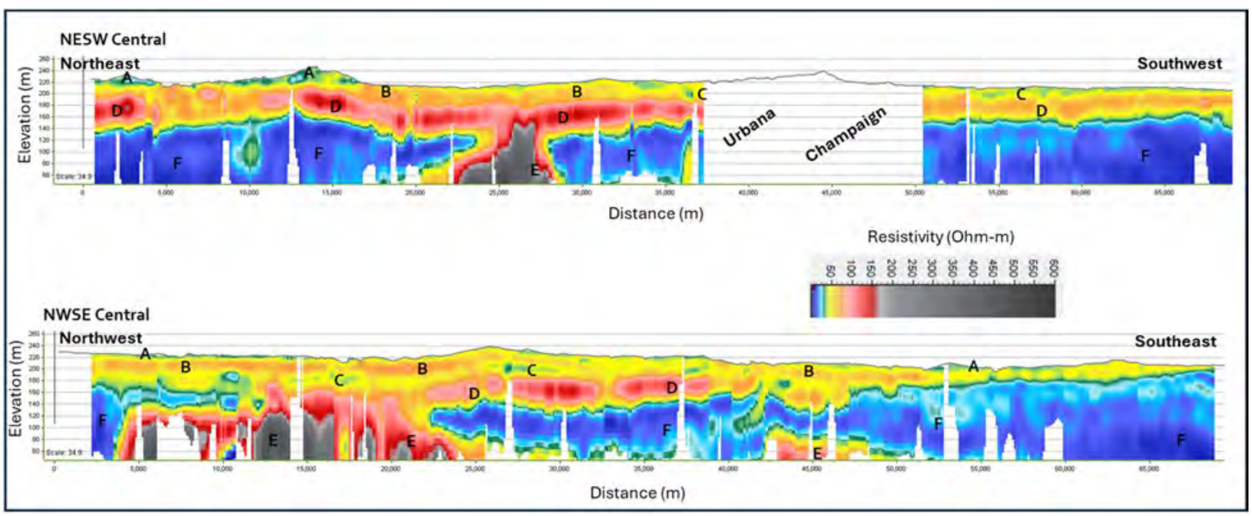


**Figure 13**. Cross sections showing resistivity values in 2-D with the interpreted geological units labeled. The geological units are correlated with the variations in resistivity values. See text for detailed description of Units A through F. The location of cross section transects NESW Central and NWSE Central are shown in Figure 6. The data gaps along the profiles (white areas) are areas where data was removed (returned data was impacted by powerlines) and/or areas where data could not be collected.

The top three unconsolidated Units A–C are easily identified due to a contrast in resistivity values between those three geological units (Figure 13). Unit C has low resistivity characteristics of the silty glacial till present in this area. Worth noting is that Unit C is not continuous and is missing in some locations (e.g., from 30,000–65,000 m along profile NWSE Central). Unit B, shows high resistivity values, corresponding to coarse-grained sandy material also known to contain some dolomite. Lastly, the thin, low resistivity, uppermost layer observed everywhere in the project area is Unit A, characterized by clayey till.

Figure 14 illustrates the P-wave seismic reflection data from Line 2 acquired along County Road 2200 N with superimposed collocated ERT results from profile 2200N. A survey of seismic Line 2 was able to image four seismic units in the area. These seismic units are identified within the unconsolidated and consolidated sediments. Units A and B–D are identified within the unconsolidated sediments and include deposits of the thin clayey till (Unit A) and a single reflector for Units B–D which comprise silty till (Unit C), and sand and gravel of both Units B and D. These sediments contain fairly weak reflectors, and as a result were grouped into the same seismic unit. Multiple bedrock units were delineated within the consolidated area, including folded strata associated with the LaSalle Anticlinorium (i.e., Dolomite assigned to Unit E). The strong seismic reflector between Units B–D and E is identified as the top of the bedrock unit associated with the shale layer of Unit F.

Strong correlation between the seismic results and the ERT results add confidence to our interpretation of geological layers in this area. Due to the nature of the ERT survey, we are unable to resolve variations between Units B, C and D, hence we grouped them together as a thick resistive layer, corresponding to seismic Units B–D. Coincidently, we are able to resolve the variation in resistivity between Units A and F, hence able to map the uppermost Unit A and the top of shale bedrock (Unit F), both correlating well with the seismic reflection results. ERT is limited in the depth of investigation compared to HTEM or seismic surveys, as a result we are not able to image the deeper dolomite bedrock in this profile.

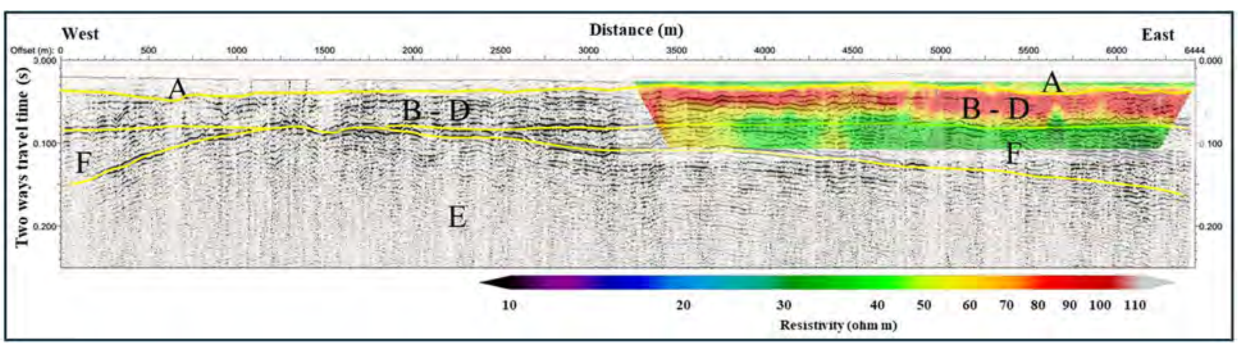


**Figure 14**. Cross section showing P-wave seismic reflection data in 2-D with superimposed ERT results acquired along County Road 2200 N, southwest of Rantoul (see Figure 6 for location of the profiles). Both sets of geophysical data can be correlated to the geological Units A–F, especially the top of bedrock or Unit F.

The inferred elevation of the bedrock surface (dashed black line) delineated by HVSR points (yellow circles) in Figure 15, is consistent with the tops of bedrock Units F and E in Profile 17020 and the top of Unit F in Profile 17067 inferred from the HTEM data. Variations in resistivity between Units D, and F and E, mark the contact between unconsolidated sand and gravels assigned to Unit D and the top of consolidated bedrock sediments assigned to Unit F and E. These data, from both HTEM and HVSR are generally consistent with the known interpretation of the elevation of bedrock surface from previous data (i.e., known borehole information) and the new borehole information from Tables 2 and 3, and Figure 6. Please note, Profile 17067 below, as shown in Figure 6, is located on the south side of Champaign County, where the deeper subsurface is predominantly shale (Figure 10). The consistency of bedrock elevation between the two geophysical datasets and the borehole data, increase confidence in our interpretation (and delineation of geological layers) of the geophysical datasets.

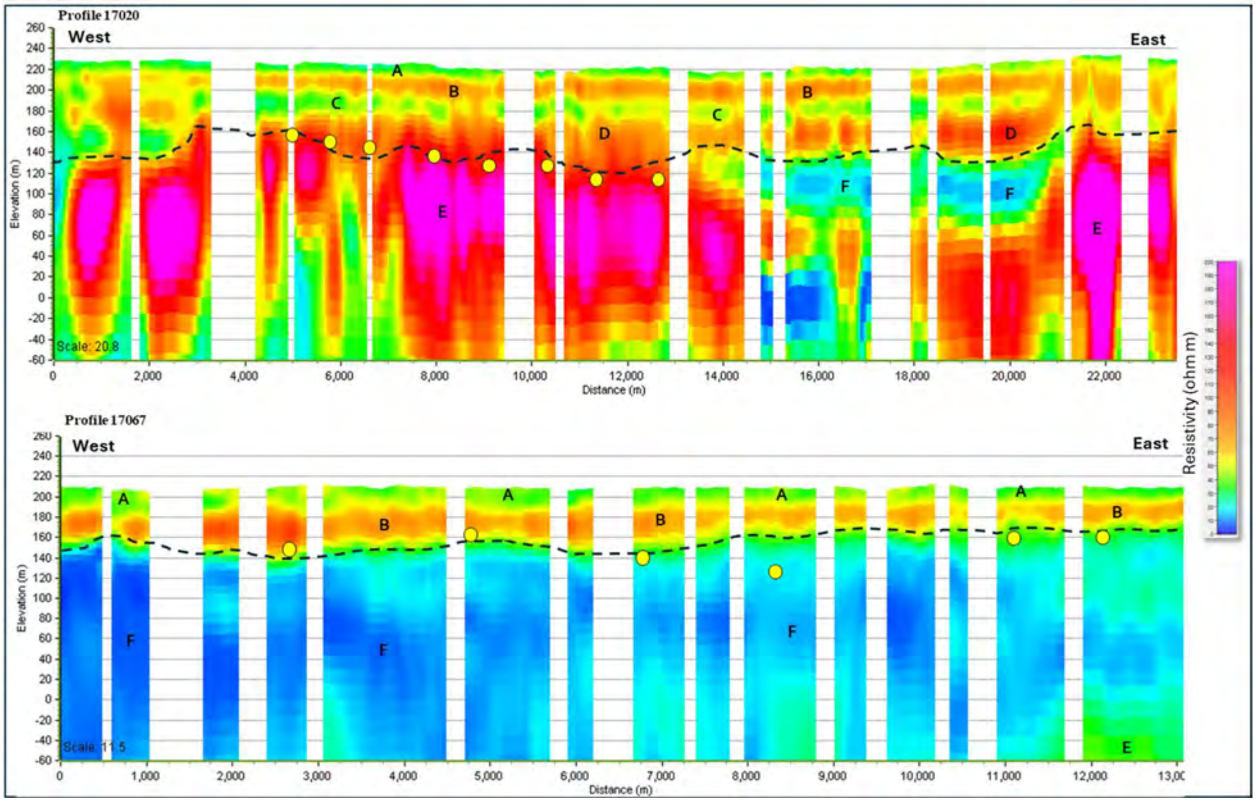


**Figure 15**. Cross sections showing the contact between unconsolidated glacial sediments (Units A–D) and the bedrock Units E and F. The dashed black line delineates the top of the bedrock. The interpolated top of bedrock is confirmed from both the resistivity and HVSR results (yellow circles). The data gaps along the profiles (white areas) are areas where data was removed (returned data was impacted by powerlines) and/or areas where data could not be collected.

### 5.2 Drill Logs

The geological information taken from the drilling logs (Figure 16) assisted in confirming and better resolving our interpretations of the geophysical data described above. More specifically, the information from the two stratigraphic test holes helped confirm the results we are seeing from the profiles within MBV (e.g., Profile 17020, Figures 15 and 16a) and those outside MBV (e.g., Profile 17067, Figures 15 and 16b). Note, due to averaging in geophysical data during processing (e.g., inversion), HTEM and ERT are both unable to resolve thin layers, especially geological layers of similar resistivity values. For example, in the unincorporated area of Flatville and the neighboring areas, HTEM is unable to resolve the thin sandy units at 10–16 m deep (Figure 16a) between the silty till layers. These units above 20 m deep in Figure 16a are all averaged and imaged as a till layer in Figures 13 and 15. The same averaging is observed in Figure 16b for the sandy units at 16–22 m deep.

Analysis of natural gamma radiation data from the unincorporated area of Flatville (Figure 16a) and Sydney (Figure 16b) confirms a correlation between geologic materials and radioisotope abundance. Generally, higher natural gamma radiation was measured in silt and fine sand, and the lowest in sand and gravel (Figure 16a, b). The well sorted coarse-grained sand and gravel have much lower gamma radiation. Overall, the bedrock measured a much higher gamma radiation as compared to the unconsolidated sediments (Figure 16b). The bedrock in the boreholes analyzed include shale, sandstone, and siltstone.

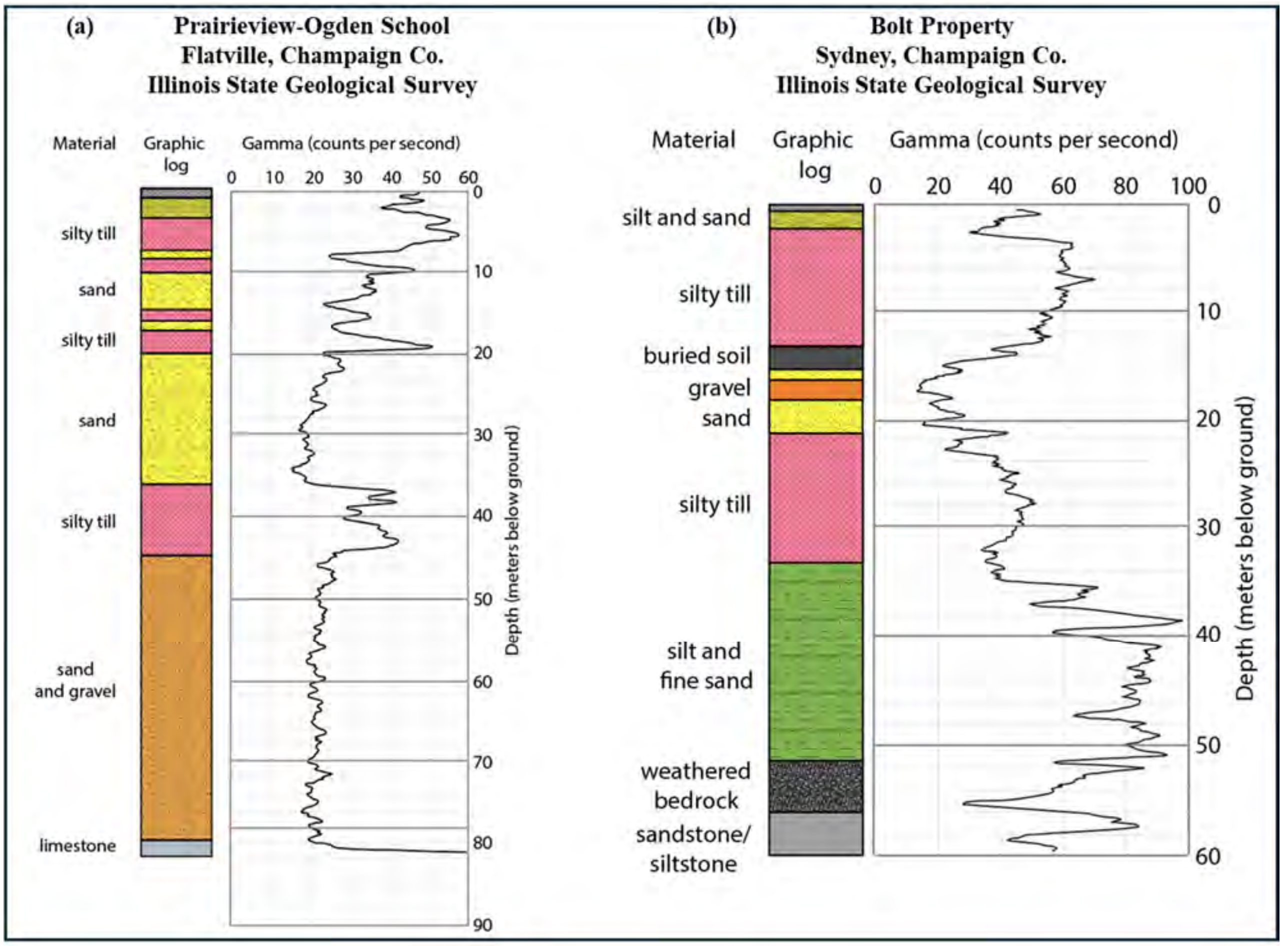


**Figure 16**. Downhole geological and geophysical data collected from the stratigraphic test holes drilled in (a) incorporated area of Flatville, IL and (b) Sydney, IL. The natural gamma radiation log data (black line on the depth graphs) were used to supplement the physical cores samples collected. A complete description of the geology is provided in tables 2 and 3.

### 5.3 Geological Modeling Results

5.3.1 Bedrock topography

The high-resolution results of the HTEM dataset and the interpolated 3-D grid allowed for the creation of a bedrock topography map that is grounded in many observations (Figure 17). The accuracy of the bedrock topography map varies somewhat across the project area. Locations with sand and gravel directly on top of shale bedrock are some of the most accurate contacts (e.g., much of the central portion of the project area), because the resistivity contrast between the two types of deposits are large and the contact is easy to identify in the data. Locations where there is fine-grained sediment on top of the shale bedrock (e.g., southeastern quadrant of project area) are expected to be less accurate, as the resistivity differences between the fine-grained sediments and shale bedrock are not large, and the inversions have a difficult time distinguishing these subtle variations. Locations where there is sand and gravel overlying carbonate bedrock are expected to be in the middle of this accuracy range, because the resistivity difference between the two materials is more variable, ranging from slight to significant.

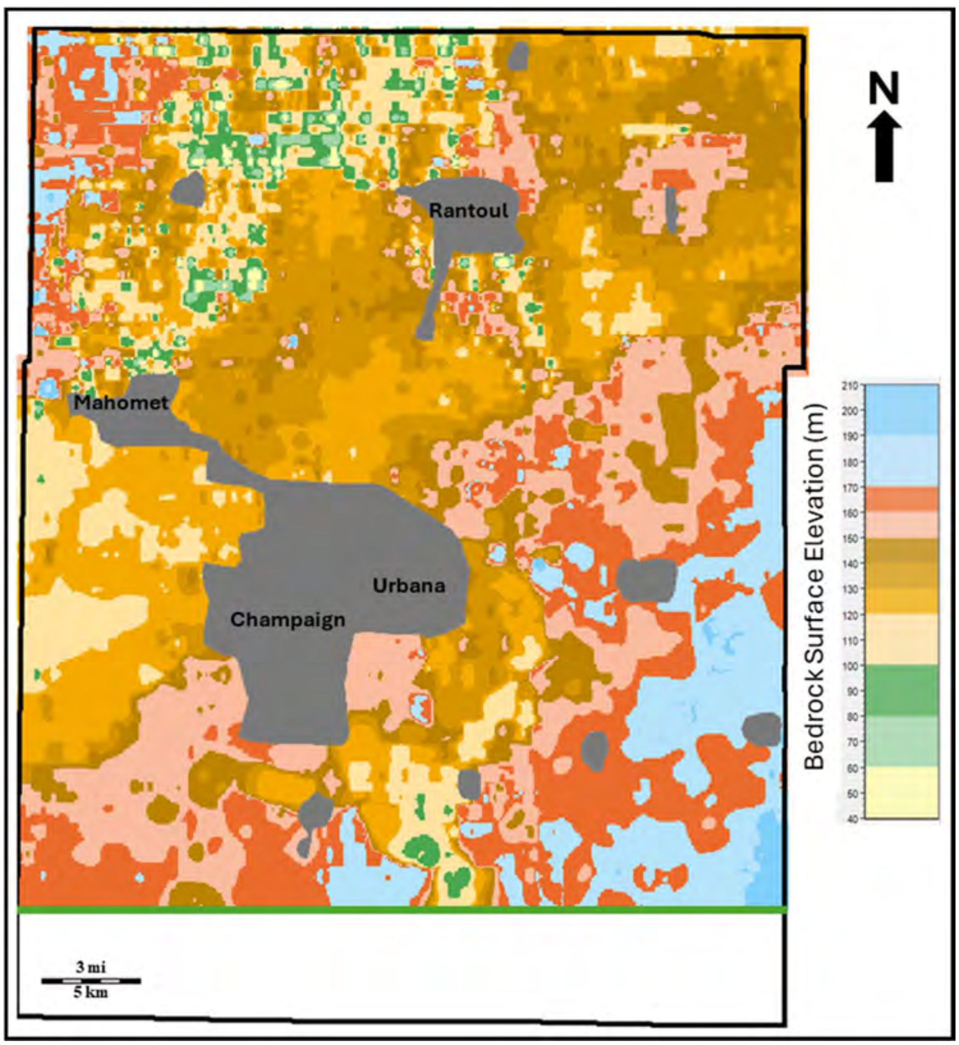


**Figure 17**. Revised bedrock topography of the project area based on the interpolated HTEM resistivity data. The green line shows HTEM data extent in southern Champaign County.

The general pattern of this bedrock topography map is more detailed than maps traditionally made using borehole geologic logs and surface geophysical data, for example Nelson (in press) map (Figure 18). This is due to the large amount of data that is used in the HTEM map, as opposed to the sparse borehole datasets available in traditional maps. The new map clearly shows the Mahomet Bedrock Valley trending SW–NE through the center of the project area. The elevations for most of the valley are in the 100–150 m elevation range. In contrast to Nelson's map, however, this HTEM-based map has a more complicated thalweg (lowest points in the valley) shape. In Nelson's (2022) map, the thalweg is clear, located in the northwestern portion of the county and in the 100–120 m elevation range, west of Rantoul. On the new map, the thalweg is in the same general location, but the shape is less well defined, and the elevations are notably both shallower and deeper than in Nelson's map, with elevations in the 50–145 m range, and with a more bullseye pattern to the surface in this area. Analysis of this surface suggests that the rocks at the bedrock surface in this area are carbonates, which are known to be karstic in other areas of Illinois. The patterns in the bedrock surface in this area are consistent with karstic surfaces made up of irregular surface patterns due to the presence of sinkholes, caves, and steeply walled channels. Karstic bedrock occurs in carbonate rocks (e.g., limestone) and is formed by the dissolution of portions of the rock, typically along joint or fracture surfaces. This dissolution forms caves connected by sinkholes. A second area where carbonate bedrock is at the bedrock surface is under and southeast of Rantoul. This area also has irregular, bullseye-rich patterns on the topographic surface.

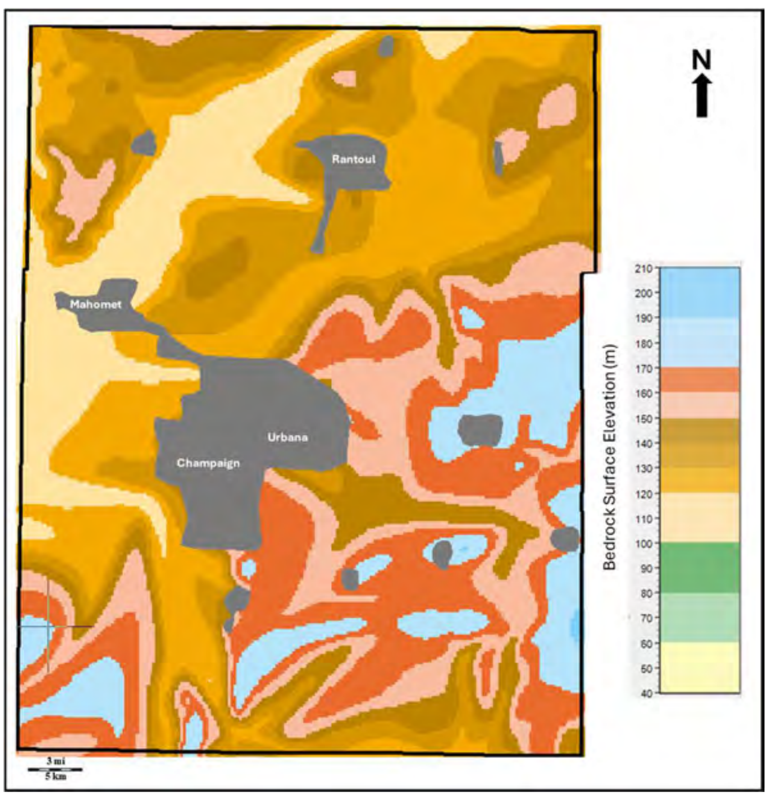


**Figure 18.** Topography of the bedrock surface (from Nelson in press). Drawing of this map was exclusively based on borehole geologic and geophysics logs and the results from surface geophysical surveys.

Another important characteristic of this new, HTEM-based bedrock topographic map is the near-horizontal, gently sloping nature in the southeastern portion of the MBV. In this area, there are near-horizontal benches, or terraces, in the 150–160 m and 160–174 m intervals. Nelson's map showed more prominent uplands in this portion of the project area.

The new map also provides more definition of the channel located east and southeast of the City of Urbana and Village of Savoy. While the presence of this channel is clear in the data, its exact position and shape is unclear because there are fine-grained sediments on top of the shale in this location, and the bedrock surface is difficult to reliably identify. It is possible that this feature is actually two channels, in positions close to those identified by Nelson (in press) (Figure 18). Targeted core samples are needed to resolve the exact distribution of these features.

# 6. DISCUSSION

## 6.1 Mahomet Aquifer Delineation

One of the primary goals of this project, was to develop a new extent or boundary for the Mahomet aquifer. Figure 19 shows the new Mahomet aquifer boundary and the 2011 boundary (Roadcap et al. 2011) on the new bedrock surface elevation map. This new Mahomet aquifer boundary is based on a combination of the new bedrock surface elevation map, the distribution of materials using the 20-category material type classification, and the Preferred conceptual model of lithologic material type distribution.

The distribution of sandy sediments, as defined by the 20-category material type classification, was analyzed to identify the potential maximum extent of potential aquifer deposits at various elevations throughout the project area. This analysis included Moderately Sorted Sands, Well Sorted Sands, Very Well Sorted Sands, and Extremely Well Sorted Sands as composing potential aquifer deposits. The results of this analysis showed that most of the Mahomet aquifer was located at or below 525 feet (160 m) elevation. Based on previous analyses of the sedimentary framework throughout the Mahomet Bedrock Valley, and a recognition that shallower aquifers occur in contact with and above the Mahomet aquifer, we identified 570 feet (174 m) as the maximum elevation of the top of the Mahomet aquifer. The new boundary of the Mahomet aquifer (Figure 19) is the result of this analysis. It is important to note that while the boundary suggests a maximum lateral extent to the deposits of the Mahomet aquifer, the distribution of the aquifer materials within this boundary are variable, or non-uniform (Figure 20). A more complete discussion of the distribution of sediments within the Mahomet aquifer boundary is presented in Sections 6.2 and 6.3.

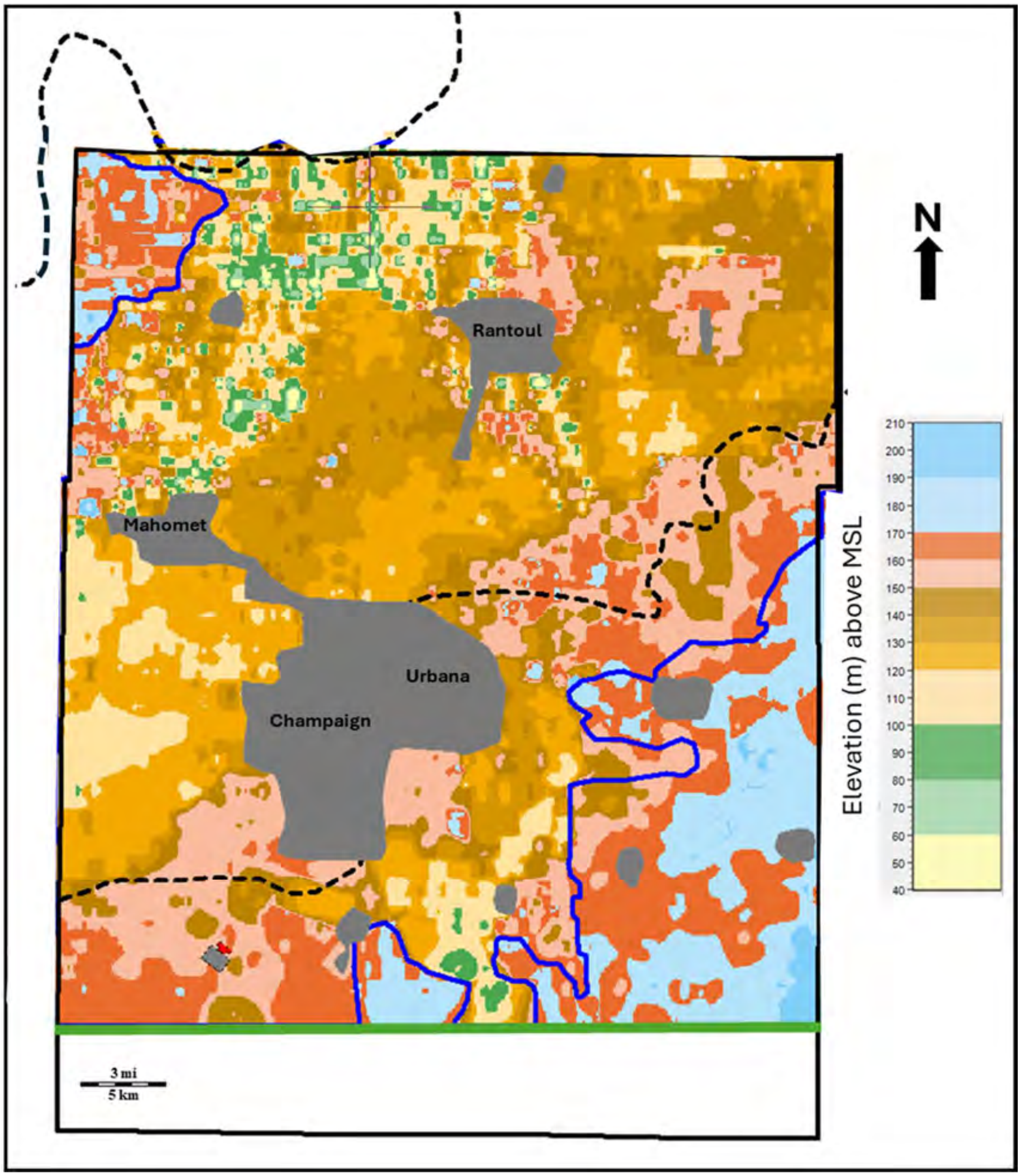


**Figure 19.** Revised boundary of the Mahomet aquifer boundary (blue line) on the bedrock topography map developed from the interpreted from HTEM data. The new boundary is compared to the boundary developed by Roadcap et al. (2011) shown as the dashed black line. The green line shows HTEM data extent in southern Champaign County.

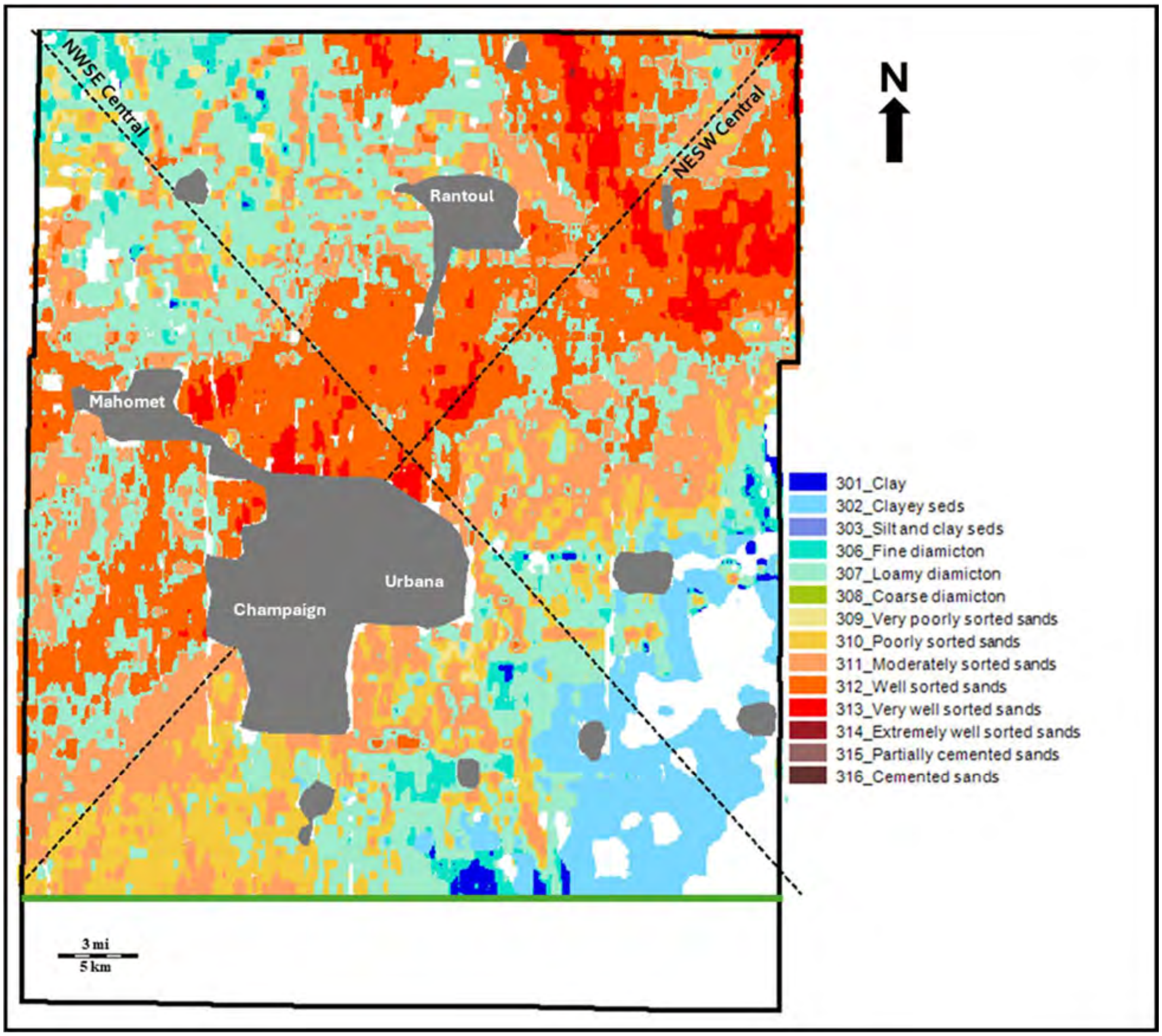


**Figure 20**. Geologic material types interpreted from HTEM data shown within the MBV at 174 m. The green line shows HTEM data extent in southern Champaign County. The dashed lines mark the locations of the 2-D cross sections (Figure 13).

### 6.2 Mahomet Aquifer Characterization

The new material-type characterization (MTC) method for interpreting the HTEM data (see Section 4.1) offers a new view into the internal makeup of the Mahomet aquifer. In the past, with limited borehole locations and ground-based geophysical data, the aquifer has generally been conceptualized as nearly homogenous throughout its distribution (Roadcap et al. 2011). The MTC method, which is based on the HTEM data, have revealed patterns and variations in the Mahomet aquifer than have never been seen before (Figure 20).

Along with aquifer thickness variations, the MTC method estimates material type changes within the aquifer (Figure 21). The distribution of these material types in the subsurface has never been resolved at this resolution before and has important implications on preferred groundwater flow paths and geologic history. Based on the HTEM data and the MTC method, much of the aquifer materials in the southern branch of the Mahomet aquifer are characterized as well-sorted to very well sorted sand (Figure 21). Those materials also likely include gravel and sand/gravel intervals that were unresolvable in the HTEM data. In the northern branch of the aquifer in Champaign County, the materials in the lowermost portions of the bedrock valley are largely characterized as well-sorted sands, but they also include newly resolved patchy intervals of loamy diamicton (silty-rich materials). In the uppermost portions of the northern branch of the aquifer, the materials, where present, are characterized mostly as loamy diamicton.

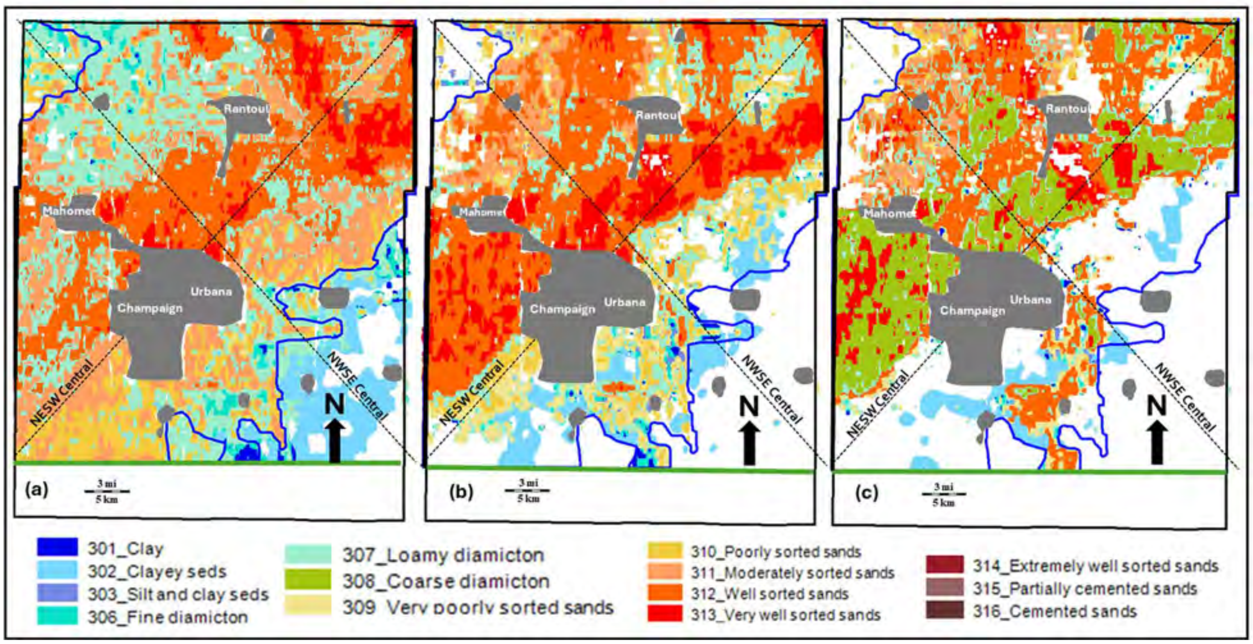


**Figure 21**. Distribution of geologic material types within the MBV at elevations of (a) 174 m, (b) 160 m, and (c) 150 m. The green line shows HTEM data extent in southern Champaign County. The blue line delineates the new boundary of the Mahomet aquifer interpreted from HTEM data. The green line shows HTEM data extent in southern Champaign County. The dashed lines mark the locations of the cross sections (Figure 13).

The southern and northern branches of the Mahomet aquifer in Champaign County are generally separated by materials characterized as loamy diamicton that trend southwest to northeast from Mahomet to Gifford. At elevations of 560 feet and above, those loamy diamicton materials are generally covered by shallow, thinner, well-sorted sands of the Mahomet aquifer (20–50 feet thick) southeast of the town of Rantoul. At Gifford, the Mahomet aquifer is generally absent (deeper elevations) or thin (higher elevations) and consistently characterized as largely loamy diamicton materials where present.

The identification of these new patterns of material-type changes has important implications on local variability of groundwater supply and local potential for aquifer recharge throughout Champaign County. Without high-density data, patterns of geologic changes must be implied, but this project has allowed us to estimate the internal structure and variability of material types based on actual, measured data. Furthermore, the scale of resolvable variability from HTEM data and the MTC method is on the order of tens to hundreds of feet, as opposed to hundreds to thousands of feet with traditional mapping methods.

## 6.3 Water Resources in and around Mahomet Bedrock Valley

### 6.3.1 Hydrostratigraphy

The material-type characterization methods predicted changes and patterns of materials within the extent of the Mahomet aquifer (Figures 20 and 21), but the MTC method was also applied to the complete geologic framework of Champaign County. That framework includes both aquifer and non-aquifer materials, both inside and outside of the Mahomet Bedrock Valley (see Section 3.4).

The material types are a valuable indicator of geologic-material variability. However, those material-types can be further categorized into hydro-type units that are most relevant to the aquifer system. The eleven material types (Figure 21), which were based on texture, were re-categorized into hydrostratigraphic units, which are based on implied hydrologic characteristics and stratigraphy. The hydrostratigraphic characterization is more reflective of aquifer characteristics and relationships in the geologic framework.

The MTC results included ten hydrostratigraphic units (1-10) and one sub-unit of the Mahomet aquifer (11) (Figure 22). Aquifer units were defined as the Carbonate aquifer, Mahomet aquifer, Lower Middle aquifer, Upper Middle aquifer, and Shallow aquifer (units 1, 3, 5, 7, and 9, respectively in Figure 22). The confining units (non-aquifer units) were defined as the Carbonate confining unit, Mahomet confining unit, Lower Middle confining unit, Upper Middle confining unit and the Shallow confining unit (units 2, 4, 6, 8, and 10, respectively in Figure 22). The Local confining deposit (unit 11) was defined as non-aquifer materials within the Mahomet aquifer.

The Carbonate aquifer is the lowermost aquifer that was characterized, and it is a carbonate bedrock unit that is overlain by the Carbonate confining unit, which is composed largely of fine-grained shale and siltstone. The Carbonate aquifer is exposed at the bedrock surface in north-central Champaign County (Figure 23) from the northern county line, through the area of Rantoul, to the area of the town of Sellers. In these areas, the Carbonate aquifer is likely hydraulically connected to the Mahomet aquifer and/or shallower aquifers.

The aquifers that overlie the Carbonate aquifer and Carbonate confining unit are generalized into four sand-and-gravel aquifer units that fill the Mahomet Bedrock Valley and partially extend outside the valley. In the lowermost elevations of the MBV, the Mahomet aquifer is the predominant aquifer unit (unit 3 in Figure 22d–h) at elevations between 425 and 550 feet. The Local Confining deposit (unit 11) is predicted consistently throughout the Mahomet aquifer, in particular near elevations of 500 and 550 feet (Figures 22d, f and 23). The Local Confining unit has not been mapped or defined previously, and its presence and distribution provide more insights into the local variability of the aquifer in Champaign County. The Lower Middle aquifer is present most predominantly throughout the south branch of the MBV and is generally separated from the underlying Mahomet aquifer by the Mahomet Confining unit (unit 4 in Figure 23) at elevations between 575 and 590 feet? (unit 5 in Figure 22b, c). The Upper Middle aquifer is less extensive and present largely in the northeast portions of the south branch of the MBV and within the north branch of the MBV (unit 7 in Figure 22a, b). The Shallow aquifer is predicted in small, local patches throughout the county, but most predominantly in an area east of Gifford. The modeled thicknesses and distributions of the sand-and-gravel aquifers are shown in Figure 24.

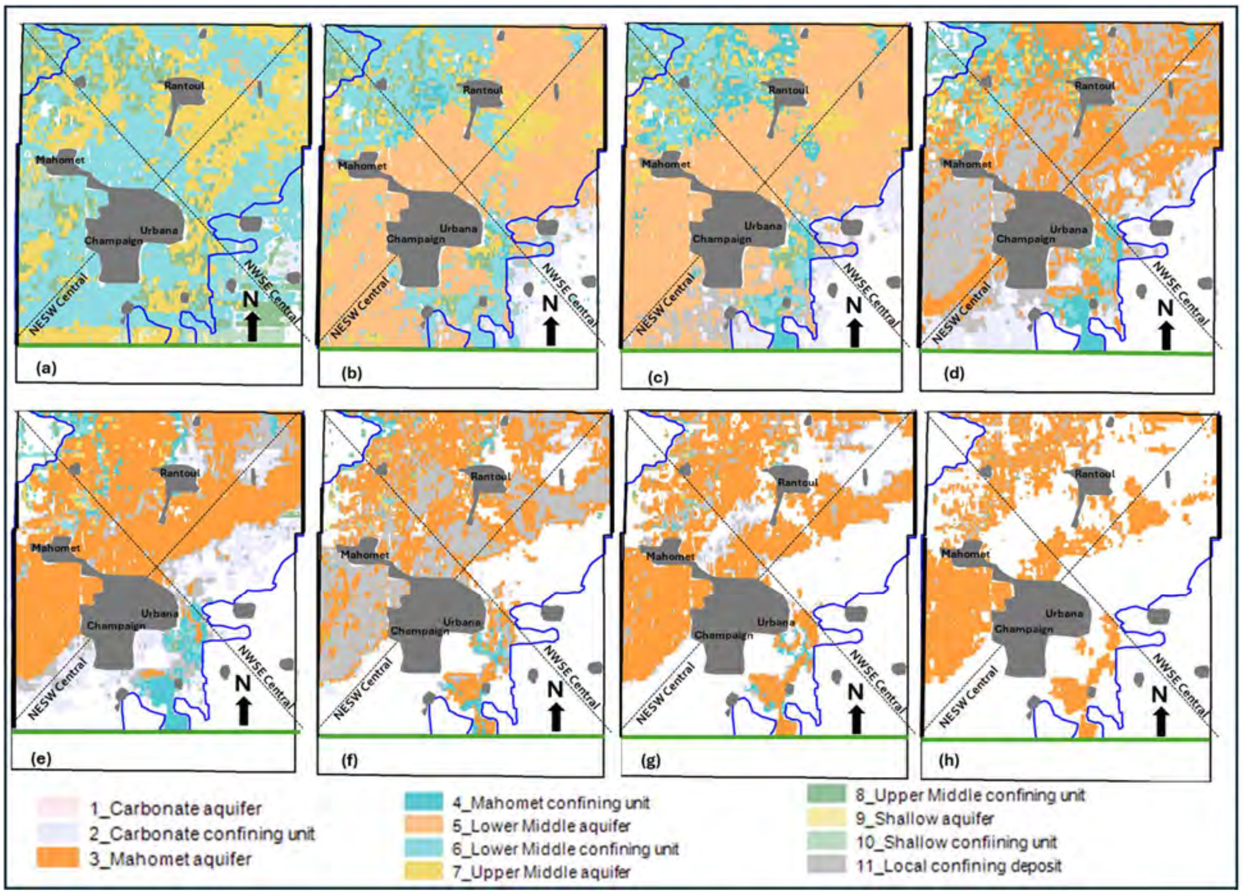


**Figure 22**. Maps showing the distribution of non-bedrock aquifer units and non-aquifer units in Champaign County at elevations of (a) 623 feet (190 m), (b) 590 feet (180 m), (c) 577 feet (176 m), (d) 551 feet (168 m), (e) 525 feet (160 m) (f) 492 feet (150 m), (g) 459 feet (140 m), and (h) 426 feet (130 m). The distributions are inferred from the interpretated from HTEM data. The green line shows HTEM data extent in southern Champaign County. The blue line is the new boundary of the Mahomet aquifer. The dashed lines mark the locations of the cross sections (Figure 23) through the hydrostratigraphic model. White areas delineate where the bedrock is present at the specified elevation (i.e., subcrops).

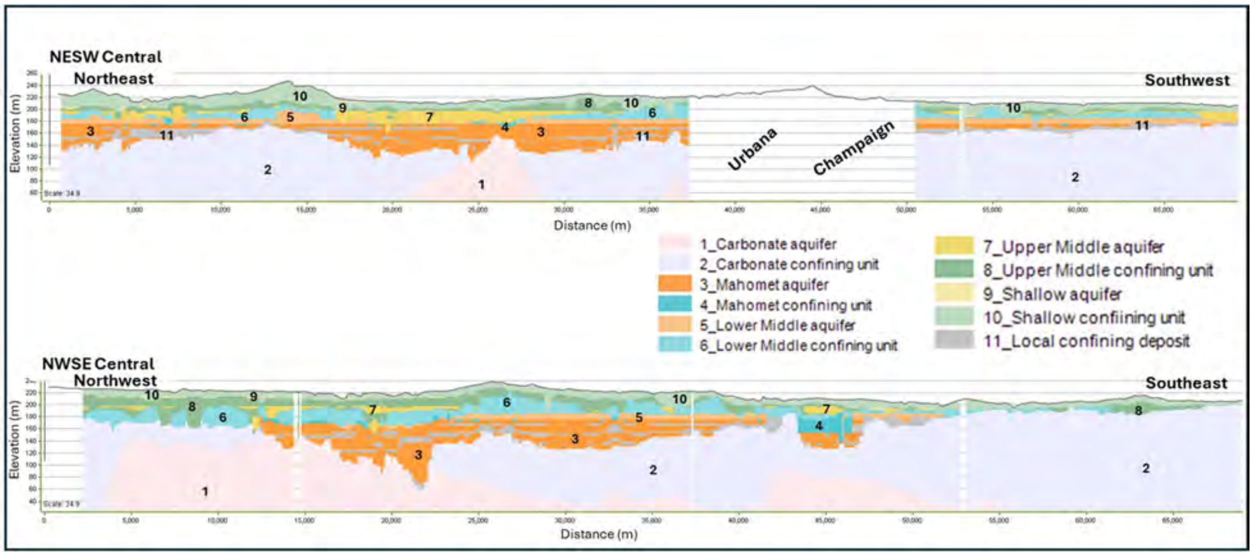


**Figure 23**. Cross sections displaying hydrostratigraphic units in 2-D in Champaign County. The units were defined from the MTC methodology (described in the text). The data gaps along the profiles (white areas) are areas where data was removed (returned data was impacted by powerlines) and/or areas where data could not be collected.

The thickness of the Mahomet aquifer changes depending on location within the MBV (Figure 24). Within the county, some of the thickest parts of the aquifer (160–200 feet thick) are present in an area about 9 miles east of the City of Champaign and near the towns of Bondville and Seymour (Figure 24a). This southern part of the aquifer extends to the northeast through the unincorporated areas of Leverett and Flatville, and Penfield where the aquifer is thinner (100–130 feet thick). Another branch of the MBV extends from the Bondville-Seymour area northward through Mahomet, Dewey and west of Ludlow (Figure 24). This branch traces the regional trend of the MBV that extends from the Illinois River near Havana across Illinois into north-central Indiana. In Champaign County, this part of the Mahomet aquifer (northern part) varies more locally in thickness between 100 and 200 feet thick (Figure 24).

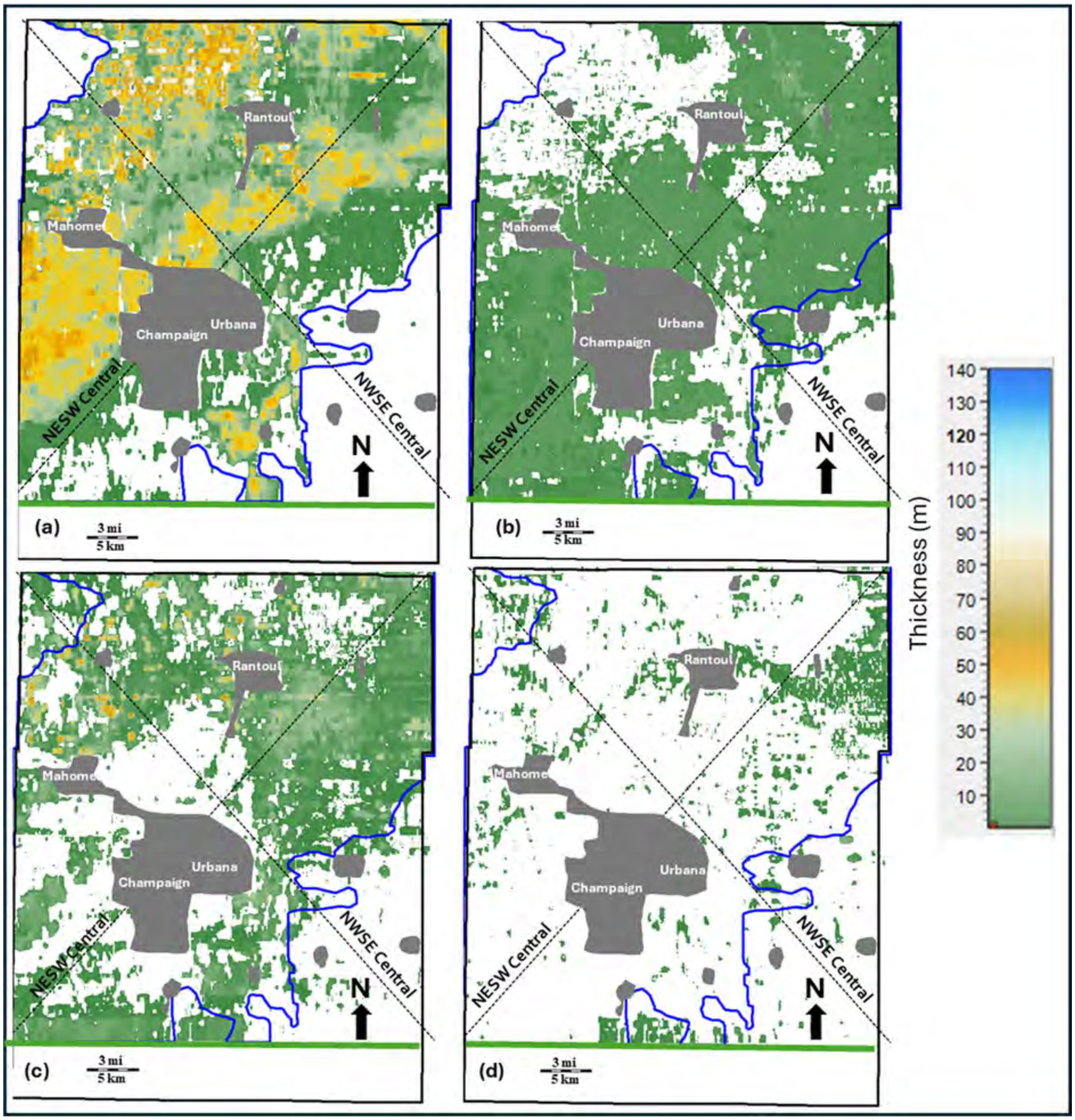


**Figure 24**. Thickness of the (a) Mahomet aquifer (b) Lower Middle aquifer (c) Upper Middle aquifer (d) Shallow aquifer in Champaign County. The green line shows HTEM data extent in southern Champaign County. The blue line is the new boundary of the Mahomet aquifer interpretated from HTEM data. The green line shows HTEM data extent in southern Champaign County. The dashed lines mark the locations of the cross sections (Figure 23) through the hydrostratigraphic model.

### 6.3.2 Buried channels

One of the goals of this project was to delineate, within the capabilities of the HTEM data, the distribution of 'buried channels' that are associated with the Mahomet aquifer. To avoid confusion as to what these channels are, how they are defined, and what they represent, we address these issues here. In the context of this project and report, we define buried channels to be channel-like features, within the HTEM material-type interpretations, which are located within and adjacent to the boundary of the Mahomet aquifer. Several of these buried channel features are observable in Figure 25. These deposits are usually composed of sandy material types (i.e., Moderately Sorted Sands to Extremely Well Sorted Sands). However, some buried channels can be composed of finer grained material types (i.e., Clay to Poorly Sorted Sands). In general, buried channels are only identifiable when they are situated within material types of contrasting resistivity (i.e., when the resistivity contrast of the channel fills with the surrounding glacial deposits makes them more distinguishable) (Figure 12). The buried channels that are most relevant to understanding the aquifers in the project area are the sandy-type channels. When we analyzed the resistivity distributions, we did identify some smaller buried channel features that were within similar material types—both sandy and fine-grained—but these were very difficult to delineate and trace.

All the channels that we observed are interpreted as representing deposits left behind from channelized flow systems (i.e., rivers) that have eroded, or scoured, the surrounding material and left behind deposits in the channel. This is a normal sedimentary process in river systems, including those under, on top of, behind, and in front of glaciers, as was the case in the processes that produced these features.

The occurrence of buried channel deposits in the project area, therefore, is not surprising, nor unusual. Their significance is primarily that, by their channelized nature, they allow focused flow of water through the surrounding volume of sediments. This results in a level of complexity in groundwater flow that is difficult to anticipate or interpret from typical hydrologic datasets, and so is only readily identifiable through the identification of these types of channelized geologic deposits. The identification of these channel features does allow for improved interpretations of groundwater flow in future analyses.

Sandy buried channel deposits were most clearly identifiable in two main areas of the project area (Figure 25). In the northwestern part of the project area, west of Rantoul, the buried channels in the northwest are largely features that suggest they were part of Unit B and represent an erosive event later in the Illinois Episode, which scoured down into the sands in the Mahomet aquifer and the overlying diamicton deposits. These deposits, when sandy enough, are portions of the Upper Middle aquifer, and can locally scour down into the Lower Middle aquifer and the Mahomet aquifer. In the east-central portion of the project area, east of Urbana and Savoy, the buried channel features appear to be older than those in the northwest and are largely scoured into the pre-existing fine-grained sediments that are on top of the shale bedrock in this region. These channel deposits, when present below 571 feet (174 m) elevation, would be considered part of the Mahomet aquifer. When the deposits are present above 571 feet (174 m) elevation, they are assigned to the Lower Middle aquifer and can serve as an additional source of water in the local areas where they are present.

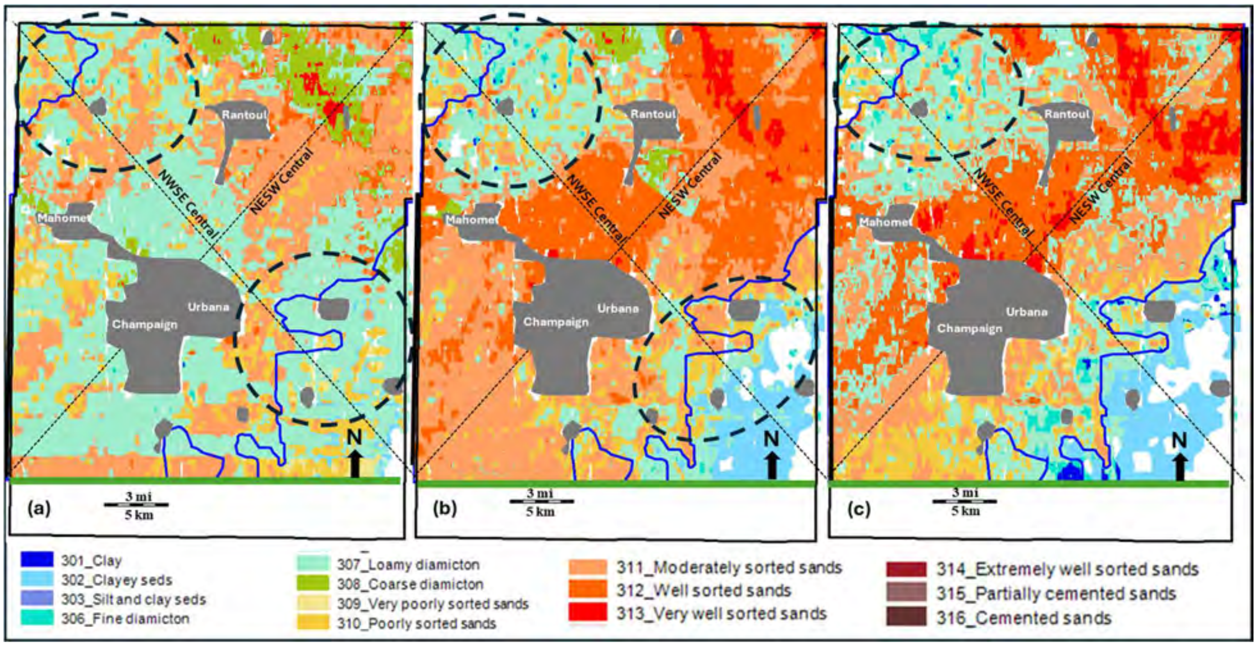


**Figure 25**. Buried channels identified in Champaign County at elevations of (a) 623 feet (190 m), (b) 590 feet (180 m), and (c) 571 feet (174 m). White areas delineate where the bedrock is present at the specified elevation (i.e., subcrops). The green line shows HTEM data extent on thein southern side of Champaign County. The blue lines delineate the new boundary of the Mahomet aquifer. The green line shows HTEM data extent in southern Champaign County. The dashed black lines mark the locations of the 2-D cross sections (Figure 23) through the hydrostratigraphic model.

### 6.4 Evaluating Aquifer Connectivity and Aquifer Recharge

The complex history of the glaciers and meltwater rivers has resulted in a complex distribution of materials. The HTEM data and MTC interpretation method have provided a way to map their distribution and identify the interconnections between the different aquifers at a very high resolution—the thickness of 3-D grid cells in the vertical direction is 6 feet (2 m) and the horizontal grid cell size is 328 feet (100 m) on each side (Figure 11). Figure 26 shows the distribution of the Mahomet aquifer and the connections with overlying aquifers. As is clear from this map, more than half of the Mahomet aquifer is in direct contact with at least one overlying aquifer. The most common interconnection is with the Mahomet aquifer and the Lower Middle aquifer. Next is an interconnection is with the Mahomet aquifer and both the Lower and Middle aquifers. While not spatially significant, there is a surprising amount of connectivity between the Mahomet and all three of the overlying aquifers. This co-occurrence is mostly in the northeastern part of the county (Figure 26).

Recharge of groundwater is a concept that is very difficult to measure and is most frequently estimated using groundwater flow models. Another method that has been used for approximate relative differences in recharge to an aquifer, particularly over larger areas, is to examine variations in the cumulative thickness of confining unit deposits overlying the aquifer (Keefer and Berg 1990). This approach was used in a map predicting relative differences in aquifer contamination potential (Berg et al. 1984), which was later used as a strategy for designing landfill compliance limitations (Hensel et al. 1991). The overriding assumption in this approach is that most recharge to a shallow aquifer is from directly above. In this situation, the thicker the overlying confining unit deposits, the longer it takes for groundwater to recharge the underlying aquifer. This approach is not meant to be a replacement for direct field observation of groundwater head gradients, or for calibrated groundwater flow models. It is recommended for use as a first-approximation tool for guiding land-use decisions in lieu of these other sources of information. Figure 27 shows the cumulative thickness of confining unit deposits overlying the Mahomet aquifer. This map identifies areas where the relative thicknesses of confining unit deposits are particularly thin (i.e., west of unincorporated area of Flatville), moderately thick (e.g., north and northwest of Champaign, north of Mahomet, west of Rantoul), or very thick (i.e., north of Rantoul).

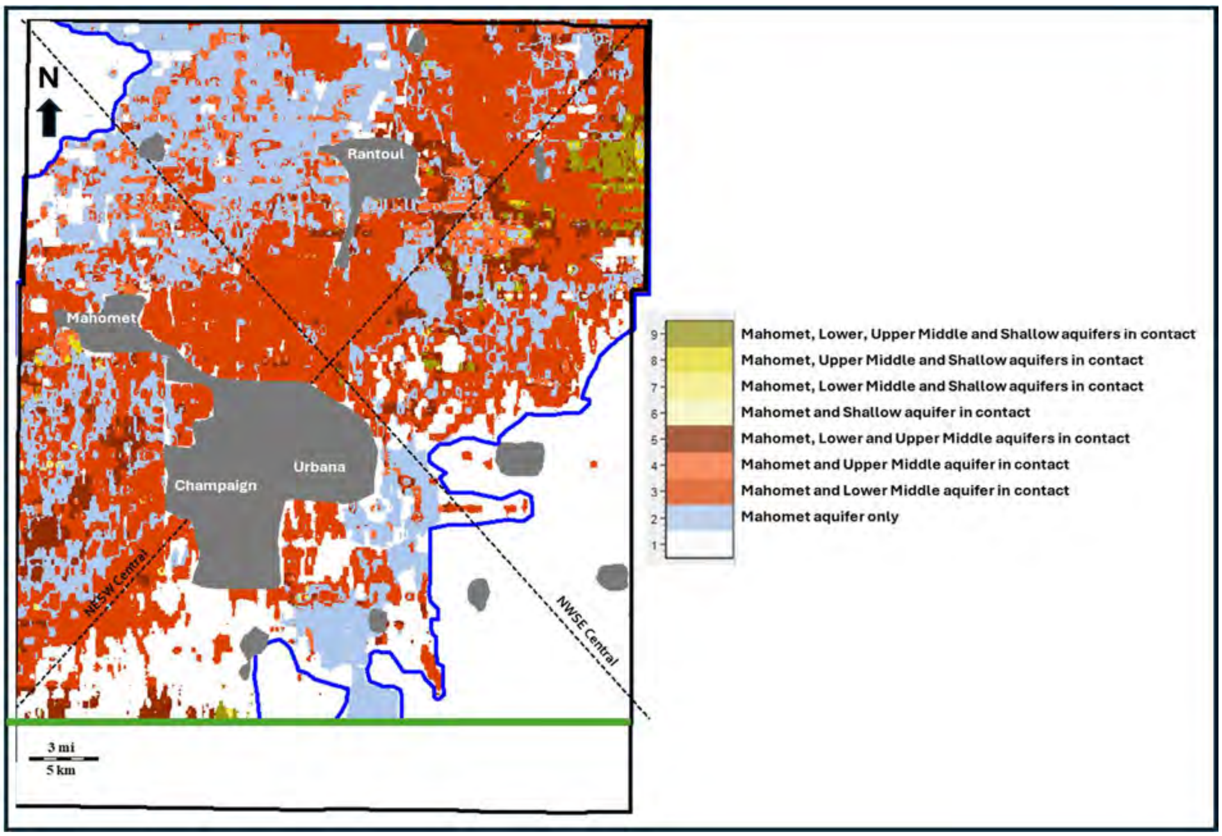


**Figure 26**. Areas of connectivity between the Mahomet aquifer and the shallower, overlying aquifers units White areas delineate where the Mahomet aquifer in not present. The green line shows HTEM data extent on thein southern side of Champaign County. The blue line is the boundary of the Mahomet aquifer interpretated from HTEM data. The black dashed lines mark the locations of the cross sections (Figure 23) through the hydrostratigraphic model.

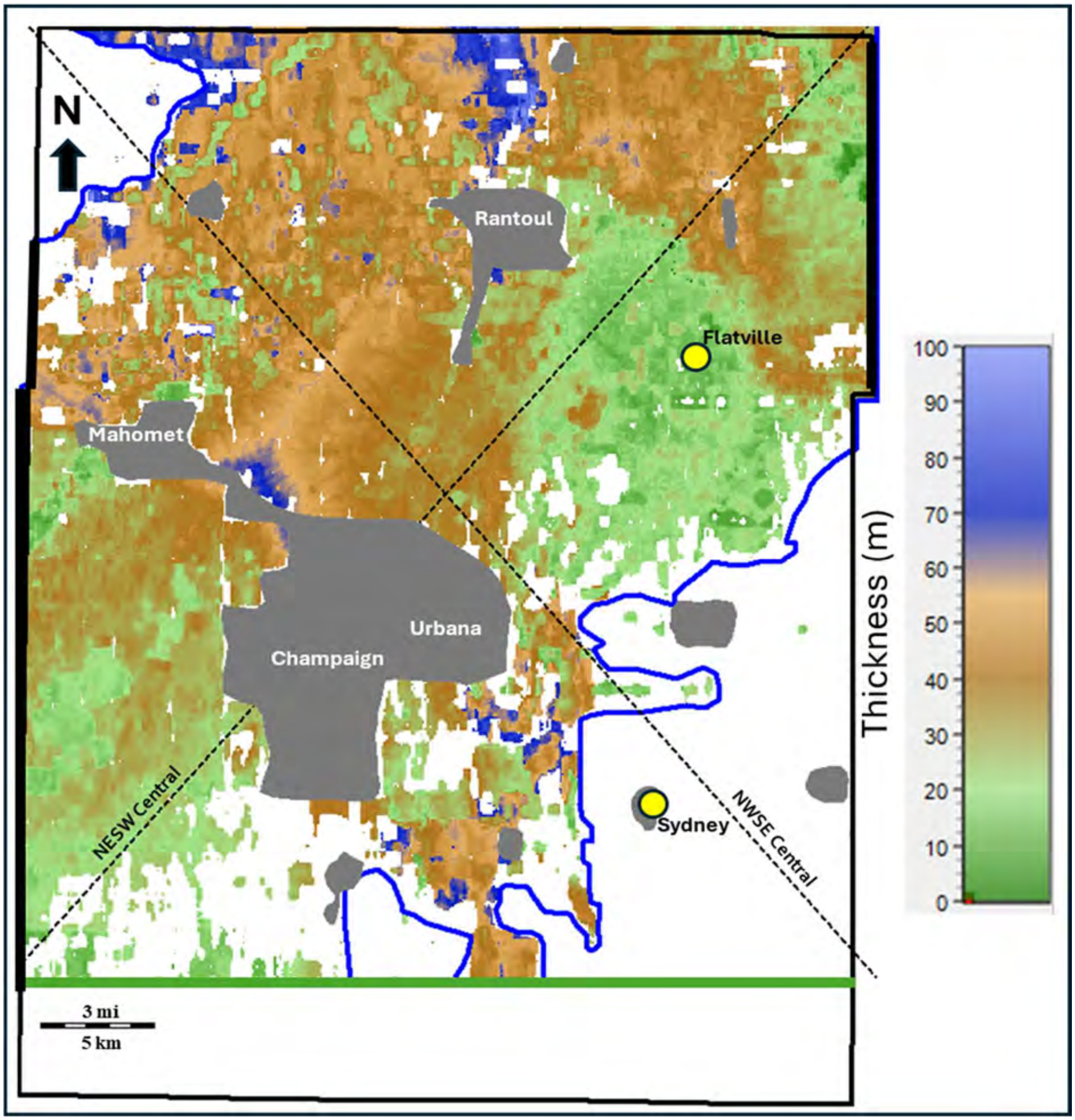


**Figure 27.** Total thickness of confining (clayey materials) above the Mahomet aquifer. White areas delineated where the Mahomet aquifer is not present. The green line shows HTEM data extent on thein southern side of Champaign County. The blue line is the boundary of the Mahomet aquifer interpreted from HTEM data. The dashed lines mark the locations of the cross sections (Figure 23) through the hydrostratigraphic model.

The Flatville and Sydney boreholes support this MTC estimate of the thickness of confining units (Figure 16). The Flatville test hole (Figure 16a) indicated thin non-aquifer materials (less than 30 feet thick) overlying thick sequences of sand, and sand and gravel (collectively up to 200 feet thick). The Sydney test hole indicated mostly non-aquifer materials (fine-grained diamicton and silt) throughout the entire thickness of sediments (180 feet, Figure 16b).

# 7. DATABASE MANAGEMENT

Processed data collected as part of this project, and the resulting maps will be made available to the public through an accessible archive, Illinois Geospatial Data Clearinghouse https://clearinghouse.isgs.illinois.edu, the HTEM project website https://htem.isgs.illinois.edu/ or the Champaign County GIS Consortium https://www.ccgisc.org/DataAndServices.aspx. ISGS will follow internal standard operating procedures for data/metadata format and quality control procedures to ensure accuracy of the data. Datasets posted on the website generally include additional information on using the dataset and background project information. All of the maps and data will be made available in a geospatial format and archived in a map projection/grid coordinate system as specified by the Champaign County. Data will be posted to the website within one year from the end of the project. Publications and maps will be posted as they are developed and accepted for publication. The raw data will be made available upon request by contacting the ISGS project manager Kisa Mwakanyamale Gilkie kemwaks@illinois.edu.

# 8. FUTURE WORK

A major priority for future work by ISGS researchers is to complete the HTEM-based characterization and map the extent of the MBV beyond Champaign County. Federally appropriated funds from ??? are currently being used for HTEM characterization of the MBV north and east of Champaign County. This leaves the mapping the rest of the MBV west of Champaign County. The importance of this characterization can be understood by comparing the updated aquifer boundaries, delineated by this project, to the USEPA Mahomet Aquifer System Sole Source Aquifer (SSA) boundary (USEPA 2015), which was delineated using the existing geological and hydrogeological data that was of lower resolution than this newly acquired HTEM data. The boundary developed by the USEPA significantly underestimates the extent of the Mahomet aquifer delineated in this project, particularly in eastern Champaign County. In addition, although not currently calculated, the unparalleled amount of information in the HTEM data suggests that potential changes to estimates of saturated thickness of the Mahomet aquifer will be significantly different from those calculated in 2015. To highlight the differences between the USEPA's 2015 characterizations and that available from HTEM data, if we consider only the sand and gravel materials of the Mahomet aquifer (i.e., aquifer sediments at or below approximately 174 m [570 feet]) (Figure 28a), the aquifer is very narrow in the eastern portion of the MBV, and USEPA did not include  a significant portion of the aquifer extent in the southeastern and eastern part of Champaign County. Additional areas within the new boundary demonstrating presence of other shallow aquifers within the Mahomet Aquifer System are illustrated in Figure 28b. We anticipate the new sediment distribution in the northern and western portions of the Mahomet Aquifer System, could further exacerbate the impacts of old boundaries and saturated thickness calculations.

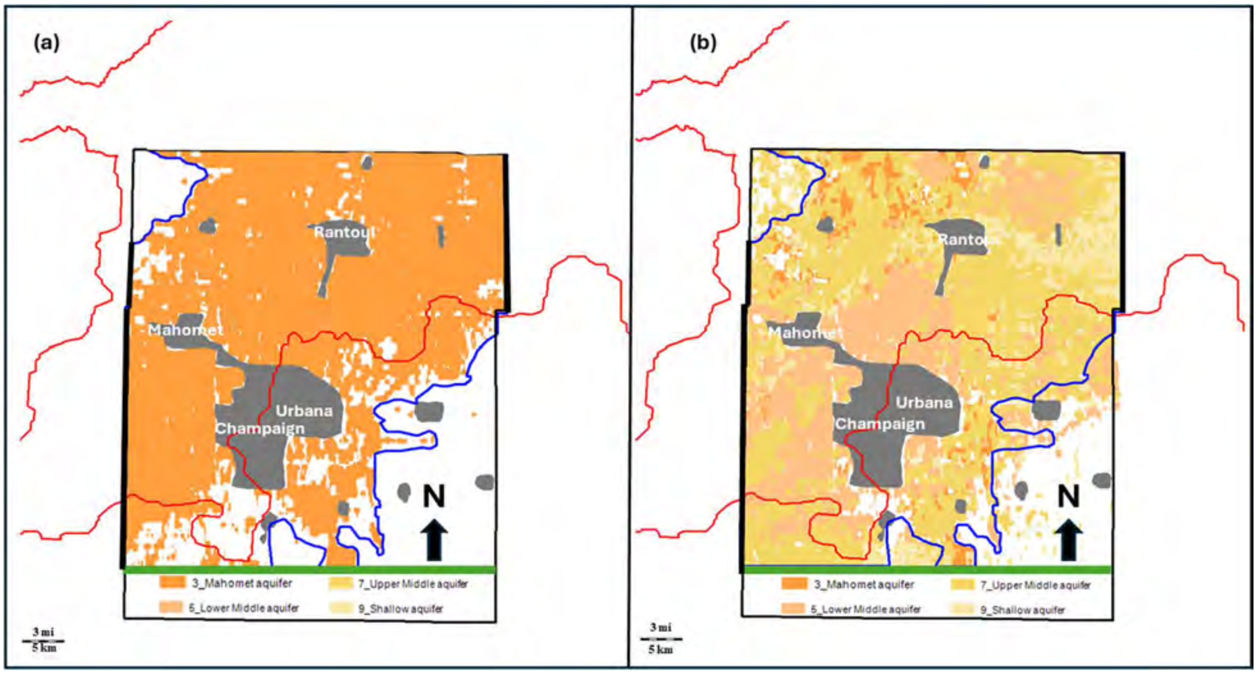


**Figure 28.** Comparison between Mahomet Aquifer System distribution within the Sole Source Project Review Area from USEPA and the new Mahomet aquifer boundary delineated from this project. (a) Comparison with Mahomet aquifer only. (b) Comparison with all other aquifers. Red is boundary from USEPA and blue is the new Mahomet aquifer boundary from HTEM.

The ISGS project researchers will continue to work with groundwater flow modelers at the ISWS to integrate the results from this project (i.e., 3-D models of geologic material types) with groundwater flow modeling efforts. Insights on interconnections of the different aquifers within the Mahomet Aquifer System, and on the variability of aquifer materials within the different aquifers, have the potential to improve predictions of groundwater flow, to reduce the uncertainty of sustainable water management decisions, and to use this improved information for associated decisions surrounding public and environmental health and economic development throughout Champaign County.

The PRI will continue to seek funds to collect additional HTEM data and other geological and geophysical data in southern Champaign County (south of County Road 500 N). The southern boundary of the Mahomet aquifer is currently mapped as following the southern boundary of the study area. This suggests the Mahomet aquifer, and Mahomet Aquifer System may extend further south of the current project boundary. Characterization of this portion of the County will be beneficial to further characterize tributary valleys to the MBV and to interpret the distribution of aquifers and confining units. The current study has suggested that additional information is needed to improve our understanding of the topography of the bedrock surface, the distribution of tributary valleys, and the nature of overlying Mahomet Aquifer System deposits. ISGS researchers will continue to advance this new MTC interpretation method for HTEM data, particularly in three major directions. The first direction for method advancement involves the direct incorporation of borehole geologic descriptions into the interpretations. As noted throughout this report, the current interpretations are grounded in the HTEM data. Borehole, seismic, and electrical resistivity tomography (ERT) data were used to further shape the conceptual models that we used in the MTC method; helping assign geologically plausible material types to the observed resistivity value distributions. Our first priority in method advancement would be to directly integrate the high-quality geologic descriptions into direct interpretations with the resistivity data. This and other advancements in the MTC interpretation method will inevitably result in changes to the interpreted material distributions and to the various aquifer and confining unit boundaries. Our second priority for method advancement is to define a workflow for generating, documenting, and publishing updated interpretations. The third priority in MTC method advancement is to develop a workflow, in collaboration with the groundwater flow modelers, for identification of joint geologically and hydrologically plausible material type distributions based on insights from groundwater modeling using HTEM-based material type interpretations. ISGS and ISWS researchers have already begun discussions in this direction, and future work will continue these discussions, leading to the formal development of this critical workflow.

# 9. CONCLUSIONS

The use of airborne geophysical mapping technology, HTEM, to map the Mahomet aquifer in Champaign County has revealed many important aspects of its geometry, not resolvable previously. The results of this project have produced the first-ever high-resolution distribution of all the aquifers and confining units in east-central Illinois, anchored to the newly acquired high-resolution HTEM data. The analysis of all the acquired data and the use of the MTC method have been essential to the identification of the aquifer and non-aquifer materials which are later categorized as aquifer units and confining units. The observations from dense HTEM data and MTC analysis have revealed material type changes within the aquifer, and the distributions of these materials have important implications for mapping preferential pathways of groundwater flow paths.

Although the Mahomet aquifer is the principal groundwater resource in Champaign County, other shallow glacial sand and gravel aquifers are also present and comprise, locally, important sources of groundwater, particularly where the Mahomet aquifer is not present. Identification of channelized Upper Middle aquifer deposits, Lower Middle aquifer and Shallow aquifer, above and intersecting with the Mahomet aquifer in several areas of Champaign County, has increased the need to better define what we call "Mahomet aquifer" in the region. These other shallow aquifers are likely hydrologically connected and locally provide a significant source of groundwater for domestic and agricultural wells. In these areas where the aquifer materials are thicker, they may provide sufficient water for commercial operations, small municipalities, or supplement the water supply of a larger municipality. These additional water resources may contribute further to the sustainable management of groundwater resources in Champaign County.

In Champaign County, the Mahomet aquifer has no surface expression as it is buried by a thick clayey till. Identification of shallow channelized sand features (filling buried channels) in the northwest and southeast parts of the project area, that locally intersect or overlie the Mahomet aquifer, could offer potential local recharge zones and additional water resources. While not present across the entire project area, these sand and gravel deposits form a continuous feature within the MBV that may be up to 30 m (~100 ft) thick.

Groundwater does not readily move through fine-grained geologic materials such as glacial tills and silt and clays, and shale bedrock because the pore spaces are small and poorly connected. The complex nature of glacial geological material and distribution of such materials in the subsurface are major factors affecting the availability, quantity, and quality of groundwater. The imaged presence of fine-grained material (i.e. non-aquifer materials) within the Mahomet aquifer makes it very challenging to predict how much water there is and how fast the water is traveling, and which direction it moves. Our high-resolution identification of a significant number of fine-grained discontinuous layers (baffles) throughout the Mahomet aquifer, will help resolve these challenges and answer all critical questions pertaining to groundwater availability, quantity, and quality. Combining this information during groundwater flow modeling, will help refine groundwater flow pattern within Mahomet aquifer.

It is important to remember that, filling the gaps where data are limited, and determining the 3-D distribution of geologic materials that either yield water or act as barriers to groundwater flow will help us understand the available resource in east-central Illinois. Understanding the geologic framework is essential to comprehend where groundwater occurs and how it behaves in the subsurface. Future integration of the Champaign County Mahomet aquifer mapping results, with the results from the ongoing northeast Mahomet aquifer (Vermillion, Iroquois, Ford, and Livingstone) mapping project interpretations, and evolution of the HTEM data interpretation method (MTC) will result in new versions of material distribution. This new and improved information of the geologic framework and hydrostratigraphy, will greatly improve accuracy of all current groundwater decision making and future groundwater predictions. Future collaboration with groundwater flow modelers will result in updated versions of material distribution, due to the constraints provided by groundwater flow calculations, which will be further improvements to our understanding of the Mahomet aquifer system in east-central Illinois.

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**1. Add the following to Section 3.0 Definitions:**

AREA OF REVIEW (AOR): The region surrounding the geologic sequestration project where underground sources of drinking water (USDWs) could potentially be endangered by the injection of carbon dioxide, as determined through computational modeling based on site characteristics and proposed operations. This has the same meaning as in 40 CFR 146.3.

CAP ROCK: the layer of impermeable rock that sits above the carbon dioxide injection zone for a CLASS VI UNDERGROUND INJECTION WELL. This layer acts as a barrier that prevents the injected carbon dioxide from escaping and mixing with drinking water aquifers.

CARBON DIOXIDE INJECTION WELL: A facility by which a stream of carbon dioxide is injected into underground geologic formations for long-term storage.

CARBON DIOXIDE SEQUESTRATION FIELD: All ground surface property under which carbon dioxide is reasonably likely to flow beneath from CARBON SEQUESTRATION ACTIVITY based on the planned capacity of the CARBON SEQUESTRATION ACTIVITY facility.

CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF): The carbon dioxide sequestration reservoir, underground equipment including but not limited to injection well penetrations, and ground surface facilities and equipment used or proposed to be used in carbon dioxide sequestration activities including all CARBON DIOXIDE INJECTION WELLS. This definition does not include pipelines used to transport carbon dioxide to a CDSF.

CARBON DIOXIDE PLUME (PLUME): The dispersing volume of carbon dioxide in the underground geological formation containing pore space.

CLASS VI UNDERGROUND INJECTION WELL PERMIT: The United States Environmental Protection Agency approved permit required for underground injection of carbon dioxide.

MAHOMET AQUIFER: The aquifer as mapped in the "Geophysical Mapping of the Mahomet Aquifer using Airborne Electromagnetic Method" by Kisa Mwakanyamale Gilkie, Donald A. Keefer, Jason F. Thomason, Steven Young, and Andrew J. Stumpf, Contract No. AJ586 report of the Illinois State Geological Survey Prairie Research Institute, University of Illinois at Urbana-Champaign submitted to the Champaign County Board February 2026 developed a new extent or boundary for the Mahomet aquifer. The report says that the aquifer includes 4 categories of sandy sediments starting at depths below 525 feet (160 m) elevation extending up to 570 feet (174 m) as the maximum elevation of the top of the Mahomet aquifer (Figure 26, page 55). The new boundary of the Mahomet aquifer in Champaign County is shown as blue lines based on analysis of the Helicopter Time-Domian Electromagnetics (HTEM) geophysics on Figure 24, Page 52 of that report.

OUTDOOR GATHERING SPACE: a venue that can accommodate a large number of people for events and gatherings. Examples include, but are not limited to, community or regional parks, beaches, and golf courses

PORE SPACE: The portion of geologic media that can store fluids such as carbon dioxide.

PORE SPACE OWNER: The person(s) who has or have title to PORE SPACE.

MAJOR SAND AND GRAVEL AQUIFER: Any underground source of potable water yielding at least 70 gallons of water per minute with less than 2,500 milligrams per liter of dissolved solids and that is at least 50 square miles in area including any area outside of Champaign County.

SAFE CCS ACT: Public Act 103-065 that is otherwise known as the Safety and Aid for the Environment in Carbon Capture and Sequestration Act.

WELL BLOWOUT: the uncontrolled high-velocity release of fluids including carbon dioxide during injection activities due to well integrity failure that can pose risks to human health and the environment.

**2. Amend Section 5.2 as follows:**

**SECTION 5.2 TABLE OF AUTHORIZED PRINCIPAL USES**

| Principal USES | Zoning DISTRICTS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CR | AG-1 | AG-2 | R-1 | R-2 | R-3 | R-4 | R-5 | B-1 | B-2 | B-3 | B-4 | B-5 | I-1 | I-2 |
| **Industrial Uses: Miscellaneous Manufacturing and Industries** | | | | | | | | | | | | | | | |
| ~~CARBON SEQUESTRATION ACTIVITY~~ CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) | | ~~M~~ B | ~~M~~ B | | | | | | | | | | | | ~~M~~ B |

Footnotes

~~31. See Section 5.5 for details on the Safety Moratorium on CARBON SEQUESTRATION ACTIVITY~~.

**2. Add new subparagraph 4.2.1 C.8. as follows:**

8. A CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) may be authorized as a County Board SPECIAL USE permit in the AG-1, Agriculture Zoning District or the AG-2 Agriculture Zoning District as a second PRINCIPAL USE on a LOT with another PRINCIPAL USE.

**3. Add new subparagraph 4.3.4 H.4.i. as follows (similar to existing 4.3.4 H.4.h. for wind farms):**

j. CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) except as PIPELINE IMPACT RADIUS regulations are required in Subsection 6.1.5.

**5. Add the following as footnote 16 under the Special Provisions for the AG-1 and AG-2 Districts in Section 5.3:**

15. LOTS in a CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) County Board SPECIAL USE Permit and intended for the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) and related maintenance and management facilities are exempt from the requirements of Section 5.3 except as such regulations are required by Subsection 6.1.5.

**6. Add new paragraph 5.4.3 F. as follows:**

G. The Rural Residential Overlay Zoning District is prohibited from being established within one-half mile of a CARBON SEQUESTRATION WELL in a CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) SPECIAL USE Permit.

**8. Add new subsection 6.1.7 as follows**:

6.1.7 CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) County Board SPECIAL USE permit

A CARBON DIOXIDE SEQUESTRATION FACILITY County Board SPECIAL USE permit may only be authorized in the AG-1 Zoning District, AG-2 Agriculture Zoning District, or I-2 HEAVY INDUSTRY subject to the following standard conditions and the SPECIAL USE Permit Application shall include information that shall demonstrate compliance with the following:

A. General Standard Conditions

(1) The area of the CARBON DIOXIDE SEQUESTRATION FACILITY County Board SPECIAL USE permit must include the following minimum areas:

a. All land that will be exposed to a noise level greater than that authorized to Class A land as established by 35 Ill. Admin. Code Parts 900, 901 and 910 under paragraph 6.1.5 I.

b. All necessary access lanes or driveways and any required new PRIVATE ACCESSWAYS. For purposes of determining the minimum area of the special use permit, access lanes or driveways shall be provided a minimum 40 feet wide area.

c. All necessary CARBON DIOXIDE SEQUESTRATION FACILITY STRUCTURES including CARBON SEQUESTRATION WELLS and

ACCESSORY STRUCTURES including electrical distribution lines, and transformers. For purposes of determining the minimum area of the special use permit, underground cable installations shall be provided a minimum 40 feet wide area.

d. All aboveground STRUCTURES and facilities shall be of a type and shall be located in a manner that is consistent with the Agricultural Impact Mitigation Agreement with the Illinois Department of Agriculture as required by paragraph 6.1.5 R.

e. All ground surface areas above the CARBOON DIOXIDE PLUME (PLUME).

(2) A SPECIAL USE Permit application for a proposed CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) that has a CARBON DIOXIDE PLUME (PLUME) that extends under another county shall include documentation that the other county has waived its authority to regulate the proposed CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) in Champaign County.

(3) The CARBON DIOXIDE SEQUESTRATION FACILITY County Board SPECIAL USE permit shall not be located in the following areas:

a. No CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) shall be allowed over, penetrate through, or store carbon dioxide under the MAHOMET AQUIFER.

b. No CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) shall be allowed over, penetrate through, or store carbon dioxide under a MAJOR SAND AND GRAVEL AQUIFER. A MAJOR SAND AND GRAVEL AQUIFER shall be identified as follows:

(a) The presence of a MAJOR SAND AND GRAVEL AQUIFER at a proposed CDSF site shall be determined through review of existing well records, review of maps of known aquifers, and aquifer pumping tests at the proposed CDSF site.

(b) Aquifer pumping tests and analysis of pumping data shall be consistent with the recommendations of the Prairie Research Institute.

(c) The results of all aquifer tests and well drillings shall be shared with the Prairie Research Institute.

(d) Champaign County reserves the right to seek a determination or judgement of the presence of a MAJOR SAND AND GRAVEL AQUIFER by the Prairie Research Institute.

c. No proposed CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) may have a CARBON DIOXIDE PLUME (PLUME) under an incorporated municipality.

d. Less than one-and-one-half miles from an incorporated municipality that has a zoning ordinance. Any request for a waiver of this minimum separation shall include the following:

(a) No CARBON DIOXIDE SEQUESTRATION FACILITY shall be located within a contiguous urban growth area (CUGA) as indicated in the most recent update of the CUGA in the Champaign County Land Resource Management Plan.

(b) The ZONING ADMINISTRATOR shall notify in writing any municipality that is located within one-and one-half miles of any proposed CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) upon the receipt of any substantial CDSF SPECIAL USE permit application in addition to any notice otherwise required.

(c) The CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) SPECIAL USE permit application shall include documentation that the applicant has provided a complete copy of the SPECIAL USE permit application to any municipality within one-and-one-half miles of the proposed CDSF.

(d) Municipal subdivision approval for any CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) land lease exceeding five years may be required by any relevant municipal authority that has an adopted comprehensive plan and when required said subdivision approval shall be necessary for compliance with Section 13.2.1.

(e) The publicized public hearing for any proposed CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) that is located within one-and-one-half miles of a municipality that has a zoning ordinance shall occur at a minimum of two BOARD meetings that are not less than 28 days apart to provide time for municipal comments during the public hearing, unless the 28-day comment period is waived in writing by any relevant municipality.

(f) For any proposed CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) that is located within one-and-one-half miles of a municipality that has a zoning ordinance, the ZONING ADMINISTRATOR shall notify said municipality of the recommendation by the BOARD after the close of the public hearing.

(g) After the initial review of the BOARD recommendation for the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF)

SPECIAL USE permit by the Environment and Land Use Committee of the COUNTY BOARD, if the Environment and Land Use Committee makes a preliminary determination to accept the BOARD recommendation, the CDSF SPECIAL USE permit shall remain at the Environment and Land Use Committee for a maximum 30-day comment period, or until the next regularly scheduled meeting, to allow comments regarding the CDSF SPECIAL USE permit to be received from any relevant municipal authority prior to the Environment and Land Use Committee recommendation to the County Board, unless the municipal comment period is waived in writing by any relevant municipality. If a CDSF is not located within one-and-one-half miles of a municipality the Environment and Land Use Committee recommendation can be referred to the County Board without a municipal comment period.

(h) If no municipal resolution regarding the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) is received from any municipality located within one-and-one-half miles of the CDSF prior to the consideration of the CDSF SPECIAL USE permit by the Champaign County Board, the ZONING ADMINISTRATOR shall provide documentation to the County Board that any municipality within one-and-one-half miles of the CDSF was provided notice of the meeting dates for consideration of the proposed CDSF SPECIAL USE Permit for both the Environment and Land Use Committee and the County Board.

(3) Right to farm

a. The owners of the subject property and the Applicant, its successors in interest, and all parties to the decommissioning plan and site reclamation plan hereby recognize and provide for the right of agricultural activities to continue on adjacent land consistent with the Right to Farm Resolution 3425.

C. Minimum Lot Standards

(1) There are no minimum LOT AREA, AVERAGE LOT WIDTH, SETBACK, YARD, or maximum LOT COVERAGE requirements for a CARBON SEQUESTRATION ACTIVITY.

(2) There is no maximum LOT AREA requirement on BEST PRIME FARMLAND.

D. Minimum Standard Conditions for Separations for CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) from adjacent USES, STRUCTURES, and property

The location of each CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) shall provide the following required separations as measured from the exterior of the above ground portion of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) and equipment including fencing:

(1) CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) fencing shall be set back from the street centerline a minimum of 300 feet from the RIGHT OF WAY of any STREET.

(2) No CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) shall be in an area where geologic strata where hazards including but not limited to faults and geologic folds could be fractured by carbon dioxide injection due to increased pressure. The applicant shall, at the discretion of the County Zoning Administrator and at the applicant's expense, hire a qualified, approved third-party qualified professionals to identify risks of injecting carbon dioxide in proximity to faults, folds, or the epicenters of previously recorded earthquakes. The qualified professionals can specify additional tests, studies and investigations to validate, confirm, or further determine assertions and findings regarding the geologic conditions, hazards and phenomena which may influence public health and safety.

(3) No CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) may be approved by the County unless computational fluid dynamics modeling is used to determine the impact area and associated releases from a potential well blowout and the potential rupture of surface equipment. Such analysis must be based on the planned storage of carbon dioxide at 12-month intervals. The resulting carbon dioxide impact area and associated releases shall be reviewed and certified by a qualified third-party professionals. The third party professionals can make recommendations for additional study, modeling, and analysis.

(4) Because CARBON DIOXIDE INJECTION WELL blowouts also have the potential to be explosive and hazardous, the distance from a CARBON DIOXIDE INJECTION WELL to a PRINCIPAL STRUCTURE, outdoor gathering space, or livestock operation shall be based on the ability to safely and successfully rescue occupants and protect the life of animals, per the following:

a. No CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) may be approved by the GOVERNING BODY unless it can be demonstrated that the COUNTY Emergency Management Agency, Local Emergency Planning Committee, the COUNTY Sheriff's Department, the relevant Fire Protection District or Department, and all other first responders in the COUNTY will be provided the equipment, training, and personnel to be able to safely and successfully rescue people near a CDSF to achieve the following goals:

(a) Evacuate occupants of PRINCIPAL STRUCTURES or any outdoor gathering space that would be exposed to concentrations between

30,000 ppm and 40,000 ppm within 15 minutes of carbon dioxide arrival time; and

(b) Limit exposure to carbon dioxide to occupants of PRINCIPAL STRUCTURES, outdoor gathering spaces and livestock operations so that concentrations do not reach 40,000 ppm.

b. In all cases, the distance between a sequestration well and a primary structure shall never be less than ½ mile (2,640 feet) to prevent exposure to carbon dioxide of 40,000 ppm or greater. The distance for this setback shall be measured from the point of the PRINCIPAL STRUCTURE foundation closest to the CARBON DIOXIDE INJECTION WELL borehole.

c. An annual reminder of evacuation routes for all PRINCIPAL STRUCTURES and outdoor gathering spaces in the AREA OF REVIEW (AOR) shall be provided to all owners or tenants of such BUILDINGS, facilities, and uses.

d. CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) equipment shall be no less than 250 feet from the property line of any lot more than 10 acres in area.

e. Additional separation may be required to ensure that the noise level required by 35 Ill. Admin. Code Parts 900, 901 and 910 is not exceeded or for other purposes deemed necessary by the BOARD.

(4) A separation of at least 5,000 feet from the end of any private air strip or airport runway.

(5) Any CARBON DIOXIDE SEQUESTRATION WELL shall be at least 2,000 feet from any public STREET, third party transmission line, or communication tower.

(6) No part of a CARBON SEQUESTRATION FIELD shall encroach beneath the property of any NON-PARTICIPATING landowner, subject to any state statute that provides for the condemnation of land for purposes of a CARBON SEQUESTRATION FIELD.

E. Standard Conditions for Design and Installation of any CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF).

(1) Any building that is part of a CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) shall include as a requirement for a Zoning Compliance Certificate a certification by an Illinois Professional Engineer or Illinois Licensed Structural Engineer or other qualified professional that the constructed building conforms to Public Act 103-0510 regarding building code compliance and conforms to the Illinois Accessibility Code.

(2) Electrical Components

a. All electrical components of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) shall conform to the National Electrical Code as amended and shall comply with Federal Communications Commission (FCC) requirements.

b. Burying power and communication wiring underground shall be minimized consistent with best management practice regarding CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) construction and minimizing impacts on agricultural drainage tile.

(3) Class VI Well Permit.

a. Any approved CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) SPECIAL USE Permit shall be required to have a U.S. EPA Class VI Well Permit per 40 CFR 146.81 *et. seq*. and a sequestration permit from the Illinois EPA prior to application for a Zoning Use Permit.

b. The CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) SPECIAL USE Permit Application shall include a copy of the Draft U.S.E.P.A. Class VI Permit and the Application shall be updated whenever changes are made.

(4) Maximum height. The height limitation established in Section 5.3 shall not apply to a CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF). The maximum height of all above ground STRUCTURES shall be identified in the application and as approved in the SPECIAL USE permit.

(5) Warning signs

a. Warning signs concerning CARBON SEQUESTRATION ACTIVITY must be placed at regular intervals on the perimeter fence around the perimeter of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) site and each injection or monitoring well and at each entrance. The sign shall provide both non-emergency and emergency contact telephone numbers

b. The warning signs shall be made with letters and numbers at least 3 inches in height and shall include the 911 address and an emergency phone number of the operator which shall be answered 24 hours a day by a live operator.

(6) No construction may intrude on any easement or right of way for a GAS PIPELINE or HAZARDOUS LIQUID PIPELINE, an underground water main or sanitary sewer, a drainage district ditch or tile, or any other public utility facility unless

specifically authorized by a crossing agreement that has been entered into with the relevant party.

F. Standard Conditions to Mitigate Damage to Farmland

(1) All underground wiring or cabling for the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) shall be at a minimum depth of 5 feet below grade or deeper if required to maintain a minimum one foot of clearance between the wire or cable and any agricultural drainage tile or a lesser depth if so authorized in the SPECIAL USE Permit.

(2) Protection of agricultural drainage tile

a. The applicant shall endeavor to locate all existing agricultural drainage tile prior to establishing any construction staging areas, construction of any necessary CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) access lanes or driveways, construction of any CDSF STRUCTURES, any common switching stations, substations, and installation of underground wiring or cabling. The applicant shall contact affected landowners and tenants and the Champaign County Soil and Water Conservation District and any relevant drainage district for their knowledge of tile line locations prior to the proposed construction. Drainage districts shall be notified at least two weeks prior to disruption of tile.

b. The location of drainage district tile lines shall be identified prior to any construction and drainage district tile lines shall be protected from disturbance as follows:

(a) All identified drainage district tile lines and any known existing drainage district tile easement shall be staked or flagged prior to construction to alert construction crews of the presence of drainage district tile and the related easement.

(b) Any drainage district tile for which there is no existing easement shall be protected from disturbance by a 40-feet wide no-construction buffer on either side of the drainage district tile. The no-construction buffer shall be staked or flagged prior to the start of construction and shall remain valid for the lifetime of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) Permit and during any deconstruction activities that may occur pursuant to the CDSF SPECIAL USE Permit.

(c) Construction shall be prohibited within any existing drainage district easement and also prohibited within any 40-feet wide no-construction buffer centered on drainage district tile that does not have an existing easement unless specific construction is authorized in writing by all commissioners of the relevant drainage district. A copy of the written authorization shall be provided to the Zoning Administrator prior to the commencement of construction.

c. Any agricultural drainage tile located underneath construction staging areas, access lanes, driveways, any common switching stations, and substations shall be replaced as required in Section 6.3 of the Champaign County Storm Water Management and Erosion Control Ordinance.

d. Any agricultural drainage tile that must be relocated shall be relocated as required in the Champaign County Storm Water Management and Erosion Control Ordinance.

e. Conformance of any relocation of drainage district tile with the Champaign County Storm Water Management and Erosion Control Ordinance shall be certified by an Illinois Professional Geologist, Landscape Architect, Land Surveyor or Engineer. Written approval by the drainage district shall be received prior to any backfilling of the relocated drain tile and a copy of the approval shall be submitted to the Zoning Administrator. As-built drawings shall be provided to both the relevant drainage district and the Zoning Administrator of any relocated drainage district tile.

f. All tile lines that are damaged, cut, or removed shall be staked or flagged in such manner that they will remain visible until the permanent repairs are completed.

g. All exposed tile lines shall be screened or otherwise protected to prevent the entry into the tile of foreign materials, loose soil, small mammals, etc.

h. Permanent tile repairs shall be made within 14 days of the tile damage provided that weather and soil conditions are suitable or a temporary tile repair shall be made. Immediate temporary repair shall also be required if water is flowing through any damaged tile line. Temporary repairs are not needed if the tile lines are dry and water is not flowing in the tile provided the permanent repairs can be made within 14 days of the damage. All permanent and temporary tile repairs shall be consistent with the general requirements of the Illinois Department of Agriculture.

i. All damaged tile shall be repaired so as to operate as well after construction as before the construction began.

j. Following completion of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) construction, the applicant shall be responsible for correcting all tile line repairs that fail, provided that the failed repair was made by the Applicant.

(3) Prior to the issuance of any Zoning Use Permit, the applicant shall provide notice to any “Drainage District,” as that term is used in the Illinois Drainage Code (70 ILCS 605/1-1 et seq.), in which any construction is proposed, or which may be affected by the project. In addition:

a. The applicant must consult and work with affected drainage districts to locate, stake and mark all the structures, facilities, ditches, drainage tiles, and rights-of-way of the affected drainage districts prior to the issuance of Building Permits.

b. The issuance of a Zoning Use Permit for construction of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) shall be conditioned on the applicant obtaining a license, easement, or right of way from any affected Drainage District consistent with 70 ILCS 605/4-30, and compliance by applicant, owner and/or operator with the construction rules and requirements of the affected drainage districts.

c. The applicant, owner, and operator shall each become a member of the Illinois state-wide One-Call Notice System (otherwise known as the Joint Utility Locating Information for Excavators or “JULIE”) and provide JULIE with all the information necessary to update its records with respect to the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF).

(3) All soil conservation practices (such as terraces, grassed waterways, etc.) that are damaged by CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) construction and/or decommissioning shall be restored by the applicant to the pre-CDSF construction condition.

(4) Topsoil replacement

For any open trenching required pursuant to CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) construction, the topsoil shall be stripped and replaced as follows:

a. The top 12 inches of topsoil shall first be stripped from the area to be trenched and from an adjacent area to be used for subsoil storage. The topsoil shall be stored in a windrow parallel to the trench in such a manner that it will not become intermixed with subsoil materials.

b. All subsoil material that is removed from the trench shall be placed in the second adjacent stripped windrow parallel to the trench but separate from the topsoil windrow.

c. In backfilling the trench, the stockpiled subsoil material shall be placed back into the trench before replacing the topsoil.

d. The topsoil must be replaced such that after settling occurs, the topsoil's original depth and contour (with an allowance for settling) will be restored.

e. All topsoil shall be placed in a manner consistent with the general requirements of the Illinois Department of Agriculture.

(5) Mitigation of soil compaction and rutting

a. The Applicant shall not be responsible for mitigation of soil compaction and rutting if exempted by the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) lease.

b. Unless specifically provided for otherwise in the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) lease, the Applicant shall mitigate soil compaction and rutting for all areas of farmland that were traversed with vehicles and construction equipment or where topsoil is replaced in open trenches.

c. All mitigation of soil compaction and rutting shall be consistent with the general requirements of the Illinois Department of Agriculture.

(6) Land leveling

a. The Applicant shall not be responsible for leveling of disturbed land if exempted by the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) lease.

b. Unless specifically provided for otherwise in the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) lease, the Applicant shall level all disturbed land as follows:

(a) Following the completion of any open trenching, the applicant shall restore all land to its original pre-construction elevation and contour.

(b) Should uneven settling occur or surface drainage problems develop as a result of the trenching within the first year after completion, the applicant shall again restore the land to its original pre-construction elevation and contour.

c. All land leveling shall be consistent with the general requirements of the Illinois Department of Agriculture.

(7) Permanent Erosion and Sedimentation Control Plan

a. Prior to the approval of any Zoning Use Permit, the Applicant shall provide a permanent soil erosion and sedimentation plan for the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) including any access road that conforms to the relevant Natural Resources Conservation Service guidelines and that is prepared by an Illinois Licensed Professional Geologist, Landscape Architect, Land Surveyor or Engineer.

b. As-built documentation of all permanent soil erosion and sedimentation improvements for the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) including any access road prepared by an Illinois Licensed Professional Geologist, Landscape Architect, Land Surveyor or Engineer shall be submitted and accepted by the Zoning Administrator prior to approval of any Zoning Compliance Certificate.

(8) Retention of all topsoil

No topsoil may be removed, stripped, or sold from the proposed SPECIAL USE Permit site pursuant to or as part of the construction of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF).

(9) Minimizing disturbance to BEST PRIME FARMLAND

a. Any CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) to be located on BEST PRIME FARMLAND shall minimize the disturbance to BEST PRIME FARMLAND as follows:

(a) The disturbance to BEST PRIME FARMLAND caused by construction and operation of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) shall be minimized at all times consistent with good agronomic practice.

(b) Existing agricultural activities shall continue as much as possible on farmland proposed for CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) but where there is no construction.

(b) Disturbance to BEST PRIME FARMLAND that is not in continued agricultural production shall be offset by establishment of a vegetative ground cover within the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) that includes the following:

i. The vegetative ground cover shall use native plant species as much as possible and shall be based on a site assessment of the site geography and soil conditions.

ii. The species selected shall serve a secondary habitat purpose as much as possible.

iii. Maintenance of the vegetative ground cover shall use a combination of management approaches to ensure safe, cost-effective, reliable maintenance while minimizing environmental risks.

iv. The plan to establish and maintain a vegetative ground cover that includes native plant species as much as possible shall be detailed in a landscape plan included in the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) SPECIAL USE permit application. The landscape plan shall include the weed control plan required by Section 6.1.5 P.(3).

G. Standard Conditions for Use of Public Streets

Any CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) Applicant proposing to use any County Highway or a township or municipal STREET for the purpose of transporting CDSF parts and/or equipment for construction, operation, or maintenance of the CDSF or Substations(s), shall identify all such public STREETS and pay the costs of any necessary permits and the costs to repair any damage to the STREETS caused by the CDSF construction, as follows:

(1) Prior to the close of the public hearing before the BOARD, the Applicant shall enter into a Roadway Upgrade and Maintenance agreement approved by the County Engineer and State's Attorney; or Township Highway Commissioner; or municipality where relevant, except for any CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) for which the relevant highway authority has agreed in writing to waive the requirements of subparagraphs 6.1.5 G.(1), (2), and (3), and the signed and executed Roadway Upgrade and Maintenance agreements must provide for the following minimum conditions:

a. The applicant shall agree to conduct a pre- CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) construction baseline survey to determine existing STREET conditions for assessing potential future damage including the following:

(a) A videotape of the affected length of each subject STREET supplemented by photographs if necessary.

(b) Pay for costs of the County to hire a consultant to make a study of any structure on the proposed route that the County Engineer feels may not carry the loads likely during the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) construction.

(c) Pay for any strengthening of STREET structures that may be necessary to accommodate the proposed traffic loads caused by the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) construction.

b. The Applicant shall agree to pay for costs of the County Engineer to hire a consultant to make a study of any structure on the proposed route that the County Engineer feels may not carry the loads likely during the CARBON

DIOXIDE SEQUESTRATION FACILITY (CDSF) construction and pay for any strengthening of structures that may be necessary to accommodate the proposed traffic loads caused by the CDSF construction.

c. The Applicant shall agree upon an estimate of costs for any other necessary roadway improvements prior to construction.

d. The Applicant shall obtain any necessary approvals for the STREET improvements from the relevant STREET maintenance authority.

e. The Applicant shall obtain any necessary Access Permits including any required plans.

f. The Applicant shall erect permanent markers indicating the presence of underground cables.

g. The Applicant shall install marker tape in any cable trench.

h. The Applicant shall become a member of the Illinois state wide One-Call Notice System (otherwise known as the Joint Utility Locating Information for Excavators or "JULIE") and provide JULIE with all of the information necessary to update its record with respect to the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF).

i. The Applicant shall use directional boring equipment to make all crossings of County Highways for the cable collection system.

j. The Applicant shall notify the STREET maintenance authority in advance of all oversize moves and crane crossings.

k. The Applicant shall provide the County Engineer with a copy of each overweight and oversize permit issued by the Illinois Department of Transportation for CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) construction.

l. The Applicant shall transport the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) loads so as to minimize adverse impact on the local traffic including farm traffic.

m. The Applicant shall schedule CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) construction traffic in a way to minimize adverse impacts on emergency response vehicles, rural mail delivery, school bus traffic, and local agricultural traffic.

n. The Applicant shall provide as much advance notice as is commercially reasonable to obtain approval of the STREET maintenance authority when it is necessary for a STREET to be closed due to a crane crossing or for any other reason. Notwithstanding the generality of the aforementioned, the Applicant will provide 48 hours notice to the extent reasonably practicable.

o. The Applicant shall provide signs indicating all highway and STREET closures and work zones in accordance with the Illinois Department of Transportation Manual on Uniform Traffic Control Devices.

p. The Applicant shall establish a single escrow account and a single Irrevocable Letter of Credit for the cost of all STREET upgrades and repairs pursuant to the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) construction.

q. The Applicant shall notify all relevant parties of any temporary STREET closures.

r. The Applicant shall obtain easements and other land rights needed to fulfill the Applicant's obligations under this Agreement.

s. The Applicant shall agree that the County shall design all STREET upgrades in accordance with the most recent edition of the IDOT Bureau of Local Roads and Streets Manual.

t. The Applicant shall provide written Notice to Proceed to the relevant STREET maintenance authority by December 31 of each year that identifies the STREETS to be upgraded during the following year.

u. The Applicant shall provide dust control and grading work to the reasonable satisfaction of the County Engineer on STREETS that become aggregate surface STREETS.

v. The Applicant shall conduct a post- CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) construction baseline survey similar to the pre-PV SOLAR FARM construction baseline survey to identify the extent of repairs necessary to return the STREETS to the pre-CDSF construction condition.

w. The Applicant shall pay for the cost of all repairs to all STREETS that are damaged by the Applicant during the construction of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) and restore such STREETS to the condition they were in at the time of the pre-CDSF construction inventory.

x. All CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) construction traffic shall exclusively use routes designated in the approved Transportation Impact Analysis.

y. The Applicant shall provide liability insurance in an acceptable amount to cover the required STREET construction activities.

z. The Applicant shall pay for the present worth costs of life consumed by the construction traffic as determined by the pavement management surveys and reports on the roads which do not show significant enough deterioration to warrant immediate restoration.

aa. Provisions for expiration date on the agreement.

bb. Other conditions that may be required.

(2) A condition of the County Board Special Use Permit approval shall be that the Zoning Administrator shall not authorize a Zoning Use Permit for the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) until the County Engineer and State's Attorney; or Township Highway Commissioner; or municipality where relevant, has approved a Transportation Impact Analysis provided by the Applicant and prepared by an independent engineer that is mutually acceptable to the Applicant and the County Engineer and State's Attorney; or Township Highway Commissioner; or municipality where relevant, that includes the following:

a. Identify all such public STREETS or portions thereof that are intended to be used by the Applicant during construction of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) as well as the number of loads, per axle weight of each load; and type of equipment that will be used to transport each load.

b. A schedule of the across road culverts and bridges affected by the project and the recommendations as to actions, if any, required with respect to such culverts and bridges and estimated of the cost to replace such culverts and bridges;

c. A schedule of the anticipated STREET repair costs to be made in advance of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) construction and following construction of the CDSF.

d. The Applicant shall reimburse the County Engineer; or Township Highway Commissioner; or municipality where relevant, for all reasonable engineering fees including the costs of a third-party consultant, incurred in connection with the review and approval of the Transportation Impact Analysis.

(3) At such time as decommissioning takes place, the Applicant or its successors in interest shall enter into a Roadway use and Repair Agreement with the appropriate highway authority.

H. Standard Conditions for Coordination with Local Fire Protection District

(1) The Applicant shall submit to the local fire protection district a copy of the site plan.

(2) Upon request by the local fire protection district, the Owner or Operator shall cooperate with the local fire protection district to develop the fire protection district's emergency response plan.

(3) Nothing in this section shall alleviate the need to comply with all other applicable fire laws and regulations.

I. Standard Conditions for Emergency and Remedial Response Plan

(1) This should be the same narrative Emergency and Remedial Response Plan document submitted for the U.S. EPA Class VI Well Permit.

(2) The Emergency and Remedial Response Plan should identify all potentially impacted environmental resources (e.g. ground water and surface water) or infrastructure (e.g. the well or nearby structures) near the injection well.

(3) The Emergency and Remedial Response Plan should confirm that any subsurface leak of carbon dioxide will immediately be reported to the Zoning Administrator and the COUNTY Executive.

(4) The Emergency and Remedial Response Plan shall address when carbon dioxide sequestration will be stopped due to mechanical failure of either a monitoring or injection well or other equipment and requires notification of such shutdown to the Zoning Administrator and the COUNTY Executive.

(5) The Emergency and Remedial Response Plan should consider, for each identified resource or infrastructure element potentially at risk, any potential adverse events that may occur including induced seismicity and shall include commitments to do the following:

a. Notify the Zoning Administrator and the COUNTY Executive and the public in addition to the U.S. EPA Underground Injection Control (UIC) Program Director when a natural or induced earthquake 1.5 to 2.0 magnitude (M) or greater has occurred, per a notification plan approved by the COUNTY Board;

b. Initiate a CO2 rate reduction plan when a natural or induced earthquake M3.5or greater is reported until an inspection and evaluation of any damage to the confining zone, any injection or monitoring wells or other wells or equipment associated with the CDSF takes place. The plan must indicate that injection of CO2:

(a) May only be resumed if it can be determined, in consultation with the U.S. EPA and , that resuming injection will not pose an undue risk to public health and safety, drinking water, or to the natural or built environment; and

(b) Must be scaled back until a potentially safe operation level has been identified and verified by a qualified third-party consultant; and

(c) Initiate a CO2 shutdown plan when a natural or induced earthquake M3.5 or greater occurs and there is confirmation of damage or there is leaking of CO2 to drinking water. This shutdown plan must include:

i. The initiation of an evacuation plan.

ii. Immediate contact with the U.S. EPA UIC Program Director to identify and implement corrective action measures.

iii. Immediate communication to the County Executive of all decisions related to such corrective action required by the U.S. EPA's UIC Program Director.

(6) The Emergency and Remedial Response Plan should describe response actions to address the identified risk scenarios including proposed evacuation plans in the event of a leak or blowout. The proposed evacuation plans shall include the following:

a. Evacuation plans for occupants of each primary structure that could be exposed to CO2 concentrations of 20,000 ppm or greater or as deemed a risk to human health by generally accepted medical or occupational authority in the event of an injection well leak or blowout that avoid travel towards the well;

b. Plans for barricading roadways that pass within modeled CO2 concentrations of 20,000 ppm; and

c. A plan for county and municipal first responders to assist with evacuation that has been coordinated and approved by such first responders.

(7) The Emergency and Remedial Response Plan should identify the personnel and equipment needed to implement the response actions. This information will likely need to be regularly updated. The information should include the following:

a. Local emergency response agencies that the facility operator must notify immediately in the event of a carbon dioxide monitoring well leak or injection well leak or blowout, including the name and contact information for each agency and include a process for annual updates.

b. CDSF operator emergency response personnel contacts for use by County and municipal emergency response personnel, including name and contact information for each personnel and a process for annual updates.

c. Recommended emergency response equipment and training required by County and municipal emergency response personnel and a plan for both providing and funding such equipment and training.

(8) The Emergency and Remedial Response Plan should include a commitment for the following:

a. The applicant shall work with emergency response personnel to design, construct, and fund a telephonic and electronic emergency alert system for individuals who live or operate businesses near the CDSF to provide alerts to evacuate in the event of an uncontrolled release of CO2 into the atmosphere, for example from the rupture of CDSF surface equipment or a well blowout; and

b. The applicant shall provide CO2 detectors with alarms to occupants of primary structures that could be exposed to concentrations of 20,000 ppm or more in the event of an uncontrolled release of CO2 into the atmosphere, for example, from the rupture of CDSF surface equipment or a well blowout. Such CO2 detectors must be provided, maintained and replaced at the applicant's expense, and monitored annually and replaced as needed to ensure continuous protection.

J. Standard Condition for Water Replacement

(1) The Application shall include a water replacement plan that addresses potential impacts to groundwater from carbon dioxide injection.

(2) The water replacement plan must include methodologies for remediating any leak of carbon dioxide, identification of alternative water sources, and show how such water would legally and financially be obtained and distributed to potentially affected groundwater users.

K. Standard Conditions for Allowable Noise Level

(1) Noise levels from any CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) shall be in compliance with the applicable Illinois Pollution Control Board (IPCB) regulations (35 *Illinois Administrative Code* Subtitle H: Noise Parts 900, 901, 910).

(2) The Applicant shall submit manufacturer's sound power level characteristics and other relevant data regarding noise characteristics of proposed CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) equipment necessary for a competent noise analysis.

(3) The Applicant, through the use of a qualified professional, as part of the siting approval application process, shall appropriately demonstrate compliance with the above noise requirements as follows:

a. The pre-development 24-hour ambient background sound level shall be identified at representative locations near the site of the proposed CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF).

b. Computer modeling shall be used to generate the anticipated sound level resulting from the operation of the proposed CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) within one mile of the proposed CDSF.

c. Results of the ambient background sound level monitoring and the modeling of anticipated sound levels shall be clearly stated in the application and the application shall include a map of the modeled noise contours within one mile of the proposed CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF).

d. The application shall also clearly state the assumptions of the computer model's construction and algorithms so that a competent and objective third party can as simply as possibly verify the anticipated sound data and sound levels.

(4) Post-construction verification of CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) operational noise level:

a. Any application for a CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) SPECIAL USE permit shall include a fee for a Post-construction CDSF Noise Study. The fee for the Post-construction CDSF Noise Study shall be held by the COUNTY and used to pay for a qualified noise consultant to conduct the Post-construction CDSF Noise Study. Any excess fees shall be refunded to the applicant upon the approval of the Noise Study and any additional fees necessary to cover the full cost of the Noise Study will be billed to the CDSF owner.

b. Within the first year of CDSF operation, the CDSF owner shall allow the COUNTY to conduct a post-construction noise study including noise monitoring, data analysis, preparation of a report intended to verify if the noise generated by the CDSF and all CARBON DIOXIDE INJECTION WELLS is in compliance with the Allowable Noise Level and in general compliance with the CDSF approval. The COUNTY shall select a qualified noise consultant to conduct the Post-construction CDSF Noise Study.

c. The post-construction noise study shall include noise monitoring at a minimum of five different representative locations within the area of the CDSF. The locations shall be agreeable to the COUNTY and to the COUNTY's qualified noise consultant and to the CDSF owner. If more than five representative locations are needed the CDSF shall bear the costs. The representative locations shall include the following:

(a) Two noise monitoring locations shall be in proximity to the worst-case and second worst case noise locations indicated in the CDSF application noise study. The actual locations may be on property that is participating in the CDSF but shall be as close as possible to non-participating property lines and NON-PARTICIPATING DWELLINGS.

(b) The other noise monitoring locations shall be distributed throughout the CDSF area.

(c) Noise monitoring locations shall not be in areas where there are undue obstructions to sound or areas that reflect or absorb sound unduly.

c. Noise monitoring timing and duration.

(a) Noise monitoring shall occur continuously during November for nighttime hours of 10 p.m. to 7 a.m., unless the COUNTY, the COUNTY's qualified noise consultant, and the CDSF owner agree to a different time and duration.

(b) Every effort should be made to conduct noise monitoring during times of maximum CDSF injection.

(c) Sound pressure level, audio recordings, and meteorological data should be collected at each monitoring location.

d. Noise measurement standards.

(a) American National Standards Institute (ANSI) S1.4-1983 (R2006) American National Standard Specifications for Sound Level Meters.

(b) ANSI S1.13-2005 (R2010) American National Standard Measurement of Sound Pressure Level in Air.

(c) ANSI S2.9-Part 3- 2013 American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound- Part 3: Short-Term Measurements with an Observer Present.

(d) ANSI S12.18-1994 (R2009) Outdoor Measurement of Sound Pressure Level.

(e) ANSI S12.100 American National Standard Methods to Determine and Measure the Residual Sound in Protected Natural and Quiet Residential Areas.

(f) 35 Ill. Admin. Code 910.105 and 106, where not in conflict with any of the above.

e. Data analysis.

(a) Care must be taken to exclude any ambient noise that may interfere with measurement of noise from the CDSF. Examples include noise from agricultural harvesting activities and noise from vehicular and train traffic. Exclusion of such data should be documented in the final report.

(b) Noise measurements should be excluded at wind speeds above 5 meter per second (11 miles per hour). Each monitoring location should have an anemometer.

(c) "Spikes" of sporadic noise, such as a motorized vehicle passing by, or a clap of thunder, or a dog barking may be eliminated from the data as long as an explanation with validation is included in the final report.

(d) Best practices shall be used in the analysis of the noise monitoring data.

f. Data reporting.

(a) The entire post-construction noise study shall be documented in a written final report that shall be approved by the GOVERNING BOARD upon a recommendation from the Champaign County Board's Environment and Land Use Committee. Approval of the written final report shall not confer approval of any exceedance of the allowable noise level.

(b) The final report shall at a minimum include the following:

i. Scaled maps of all injection CARBON DIOXIDE INJECTION WELL locations, all monitoring locations, all residences and/or PRINCIPAL STRUCTURES or BUILDINGS within one mile of any CARBON DIOXIDE INJECTION WELL.

ii. Continuous sound measurements at all wind speeds that occurred during monitoring and charts illustrating the time series measurements.

iii. One-third octave band analysis of data recorded at each monitoring location.

iv. Use monitoring results to assess sound measurements over the range of sound frequencies to estimate the total noise level while the CARBON DIOXIDE INJECTION WELLS were in operation. Present these results in charts and tables as appropriate.

v. Compare the monitoring results to the allowable noise level and highlight any exceedances.

vi. Include a written narrative conclusion regarding how well the monitored results compare to the allowable noise level and the predicted sound levels for the CDSF. Explain any unfavorable results or exceedances of the allowable noise level.

g. Amend the Special Use Permit. Any exceedance of the allowable noise level shall require an amendment to the CDSF SPECIAL USE permit. The amendment to the CDSF SPECIAL USE permit shall include any changes to CDSF operation that are necessary to comply with the allowable noise level. An application for any required amendment to the CDSF SPECIAL USE permit shall be received (with full application fees) within 180 days of the County Board approval of the post-construction noise study.

(5) After construction of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF), the Zoning Administrator shall take appropriate enforcement action as necessary to investigate noise complaints in order to determine the validity of the complaints and take any additional enforcement action as proves warranted to stop any violation that is occurring, including but not limited to the following:

a. The Zoning Administrator shall make the Environment and Land Use Committee aware of complaints about noise that have been received by the Complaint Hotline.

b. If the Environment and Land Use Committee determines that the noise is excessive, the Environment and Land Use Committee shall require the Owner or Operator to take reasonable steps to mitigate the excessive noise.

L. Standard Condition for Endangered Species Consultation

The Applicant shall apply for consultation with the Endangered Species Program of the Illinois Department of Natural Resources. The Application shall include a copy of the Agency Action Report from the Endangered Species Program of the Illinois Department of Natural Resources or, if applicable, a copy of the Detailed Action Plan Report submitted to the Endangered Species Program of the Illinois Department of Natural Resources and a copy of the response from the Illinois Department of Natural Resources.

M. Standard Condition for Historic and Archaeological Resources Review

The Applicant shall apply for consultation with the State Historic Preservation Officer of the Illinois Department of Natural Resources. The Application shall include a copy of the Agency Action Report from the State Historic Preservation Officer of the Illinois Department of Natural Resources.

N. Standard Condition for Acceptable Wildlife Impacts

The CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) shall be located, designed, constructed, and operated so as to avoid and if necessary mitigate the impacts to wildlife to a sustainable level of mortality.

O. Screening and fencing

(1) Perimeter fencing

a. CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) equipment and structures shall be fully enclosed and secured by a fence with a minimum height of 7 feet.

b. Knox boxes and keys shall be provided at locked entrances for emergency personnel access.

c. Vegetation between the fencing and the LOT LINE shall be maintained such that NOXIOUS WEEDS are controlled or eradicated consistent with the Illinois Noxious Weed Law (505 ILCS 100/1 et seq.). Management of the vegetation shall be explained in the application.

(2) Screening

a. A visual screen shall be provided around the perimeter of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) STRUCTURES, electrical transformer(s), cabling, switching station, electrical cabling from the CDSF to the substations(s), ancillary equipment, meteorological station, maintenance and management facilities, as follows:

(a) The visual screen shall be provided for any part of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) that is visible to an existing DWELLING or residential DISTRICT except that the visual screen shall not be required if the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) is not visible to a DWELLING or residential DISTRICT by virtue of the existing topography.

(b) The visual screen shall be waived if the owner(s) of a relevant DWELLING(S) have agreed in writing to waive the screening requirement and a copy of the written waiver is submitted to the BOARD or GOVERNING BODY.

(c) The visual screen shall be a vegetated buffer as follows:

i. A vegetated visual screen buffer that shall include a continuous line of native evergreen foliage and/or native shrubs and/or native trees and/or any existing wooded area and/or plantings of tall native grasses and other native flowering plants and/or an area of agricultural crop production that will conceal the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) from view from adjacent abutting property may be authorized as an alternative visual screen subject to specific conditions.

ii. Any vegetation that is part of the approved visual screen buffer shall be maintained in perpetuity of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF). If the evergreen foliage below a height of 7 feet disappears over time, the screening shall be replaced.

iii. The continuous line of native evergreen foliage and/or native shrubs and/or native trees shall be planted at a minimum height of 5 feet tall and shall be planted in multiple rows as required to provide a 50% screen within 2 years of planting. The planting shall otherwise conform to Natural Resources Conservation Service Practice Standard 380 Windbreak/Shelterbreak Establishment except that the planting shall be located as close as possible to the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) fence while still providing adequate clearance for maintenance.

v. An area of agricultural crop production may also be authorized by the BOARD as an alternative visual screen buffer with a width of planting as authorized by the BOARD provided that the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) perimeter fence is opaque. Any area of crop production that is used as a vegetated visual screen shall be planted annually and shall be replanted as necessary to ensure a crop every year regardless of weather or market conditions.

vi. Any vegetated screen buffer shall be detailed in a landscape plan drawing that shall be included with the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) SPECIAL USE Permit application.

P. Standard Condition for Liability Insurance

(1) Commencing with the issuance of a Zoning Use Permit, the Owner or Operator of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) shall maintain a current general liability policy covering bodily injury and property damage with minimum limits of a least $5 million per occurrence and $50 million in the aggregate.

(2) Self-insuring or self-bonding shall not be allowed.

(3) The general liability policy shall identify landowners in the SPECIAL USE permit as additional insured.

(4) The COUNTY and its officers, appointed and elected officials, employees, contractors, and agents (the “COUNTY Affiliates”) and all affected Road Districts and their officers, appointed and elected officials, employees, contractors, and agents (the “Road District Affiliates”) shall be included as additional insureds on the insurance certificate(s), endorsement(s) and policies for all aspects of construction of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) and for all automobiles owned, leased, hired or borrowed, as applicable for the CDSF.

(5) The coverage shall contain no special limitations on the scope of protection afforded to the COUNTY and the COUNTY Affiliates or the affected Road Districts and the Road Districts’ Affiliates. The insurance coverage of the Owner or Operator shall be primary and noncontributory for the additional insureds. The applicant shall file the original certificate of insurance with the Zoning Administrator upon issuance of a CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) Zoning Use Permit and prior to the commencement of construction, corresponding policies and endorsements to be provided within sixty (60) days of issuance, and at each subsequent renewal, at least annually thereafter until completion of construction.

(6) The applicant shall defend, indemnify, and hold harmless the COUNTY and its officers, appointed and elected officials, employees, contractors, and agents (collectively and individually, the "Indemnified Parties") from and against any and all claims, demands, losses, suits, causes of action, damages, injuries, costs, expenses, and liabilities whatsoever, including reasonable attorney's fees, relating to the construction of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF). This includes, without limitation, liability for property damage or personal injury (including death or illness), whether said liability is premised on contract, tort, or any violations of local, state, or federal law, including the Illinois Constitution and the United State Constitution (including without limitation strict liability or negligence) or any acts or omissions of the applicant or the owner under this Ordinance or the Special Use Permit. This general indemnification shall not be construed as limiting or qualifying the County's other indemnification rights available under the law.

Q. Operational Standard Conditions

(1) Maintenance

a. The Owner or Operator of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) must submit, on an annual basis, a summary of operation and maintenance reports to the Environment and Land Use Committee and any other operation and maintenance reports as the Environment and Land Use Committee reasonably requests.

b. Any physical modification to the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) that increases the number of CDSF SEQUESTRATION WELL or structures and/or the land area occupied by the CARBON DIOXIDE SEQUESTRATION FIELD shall require a new County Board SPECIAL USE Permit.

c. Like-kind replacements shall not require recertification provided replacement is done in a fashion similar to the original installation but shall require written approval of the County Zoning Administrator.

d. Prior to making any physical modification (other than a like-kind replacement), the owner or operator shall confer with a relevant third-party certifying entity and a professional engineer determined by the County Zoning Administrator to determine whether the physical modification requires recertification. The cost of the third-party certifying entity and professional engineer shall be paid by the owner or operator.

e. Any replacement of equipment that is not a like-kind replacement shall require a new special use permit.

(2) Materials Handling, Storage and Disposal

a. All solid wastes related to the construction, operation and maintenance of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) shall be removed from the site promptly and disposed of in accordance with all federal, state and local laws.

b. All hazardous materials related to the construction, operation and maintenance of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) shall be handled, stored, transported and disposed of in accordance with all applicable local, state and federal laws.

(3) Vegetation management

a. The CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) SPECIAL USE permit application shall include a weed control plan for the total area of the SPECIAL USE permit including areas both inside of and outside of the perimeter fencing.

b. The weed control plan shall ensure the control and/or eradication of NOXIOUS WEEDS consistent with the Illinois Noxious Weed Law (505 ILCS 100/1 et seq.)

c. The weed control plan shall be explained in the application.

(4) Containment of carbon dioxide

a. Once the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) begins to inject carbon dioxide, the owner or operator shall submit semi-annual reports to the Zoning Administrator that identify the actual horizontal spread and vertical rise of the underground carbon dioxide PLUME, and the extent of subsurface pressure changes caused by the CDSF. These reports shall be required until such time as the U.S EPA determines the post closure care of the project is complete or as otherwise might be determined by the Illinois EPA. The purpose of this requirement is to verify that the injected carbon dioxide is following models approved by the U.S. EPA and not escaping containment or moving to unauthorized areas which would be considered trespass.

b. The applicant shall submit semi-annual reports that compare the location of the carbon dioxide PLUME to that which was modeled and approved by the U.S. EPA. When such reports show the footprint of the PLUME is within 90% of that which was approved, injection of carbon dioxide shall cease to avoid trespass. Resuming injection may only occur if it can be demonstrated to the COUNTY Board, in consultation with an approved third-party qualified professional, that such injection of carbon dioxide can continue without risking trespass or posing a hazard to any MAJOR SAND AND GRAVEL AQUIFER. This may require adjusting the rate and or volume of carbon dioxide injected, or other methods may be put in place to prevent trespass.

c. Carbon dioxide that has migrated horizontally beyond the approved underground shall be considered a trespass, requiring immediate cessation of carbon dioxide injection and the following:

d. If, despite the required reporting or agreed-to actions put in place to allow carbon dioxide injection to continue without trespass, it is determined that carbon dioxide has migrated beyond the approved underground PLUME, the operator shall cease all injection of carbon dioxide and compensate the affected non-consenting landowners per requirements and procedures set forth in the SAFE CCS Act.

e. If the carbon dioxide PLUME is moving vertically toward the CAP ROCK at a rate faster than anticipated:

(a) The applicant or owner shall pay an approved third-party qualified professional to perform necessary field and office studies in order to submit documentation to the County Board demonstrating that the pace of the vertical rise is not related to a path created by a fault or a fissure or fracture that was either unmapped or created by an induced earthquake that could allow carbon dioxide to move into an aquifer or leak into overlying strata or the atmosphere.

(b) If the submitted studies and documentation do not demonstrate that the pace of the vertical rise is not related to a path created by a fault or a fissure or fracture that was either unmapped or created by an induced earthquake that cannot be demonstrated, the COUNTY Executive shall contact the U.S. EPA's UIC Program Director of their concern for a potential leak, along with a request to the U.S. EPA to halt carbon dioxide injection, until such time as it can be determined that carbon dioxide injection can be safely resumed.

(5) Subsurface leaks

a. The CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) operator must immediately notify the COUNTY Emergency Management Agency and the COUNTY Executive whenever an injection or monitoring well experiences subsurface leaks or malfunctions to the extent it no longer can sample in all required zones.

b. The owner or operator must demonstrate that coordination with the U.S. EPA has occurred and shall report measures taken to contain the leak to the COUNTY Executive.

c. If the COUNTY Board determines the agency's actions do not adequately ensure the protection of an underground source of drinking water, the COUNTY Board may appeal such remediation to the U.S. EPA Board of Appeals, as applicable, or seek other remedies provided by law. Costs of any appeal shall be paid for by the owner(s) or operator(s) of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF).

(6) Water quality reporting

a. One year after the date that carbon dioxide injection begins at a CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) and every year thereafter for the duration of CDSF, the operator shall have an approved third-party qualified professional to submit water quality reports to the Zoning Administrator. The water quality reports shall highlight any changes in pH, metals, cations, anions, or chemical compounds that are in the groundwater and shall include a written narrative to explain whether or not carbon dioxide has leaked from the CDSF and migrated into groundwater that is a source of drinking water.

b. Groundwater that is a source of drinking water and that is contaminated by a carbon dioxide leak from a CDSF must be replaced with an alternate water supply, pursuant to the water replacement plan submitted to and approved by the COUNTY Board as part of this SPECIAL USE permit.

R. Standard Condition for Decommissioning and Site Reclamation Plan

(1) The Applicant shall submit a signed decommissioning and site reclamation plan conforming to the requirements of paragraph 6.1.1 A.

(2) In addition to the purposes listed in subparagraph 6.1.1 A.4. the decommissioning and site reclamation plan shall also include provisions for anticipated repairs to any public STREET used for the purpose of reclamation of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) and all costs related to removal of access driveways.

(3) The decommissioning and site reclamation plan required in paragraph 6.1.1 A. shall also include the following:

a. A stipulation that the applicant or successor shall notify the GOVERNING BODY by certified mail of the commencement of voluntary or involuntary bankruptcy proceeding, naming the applicant as debtor, within ten days of commencement of the proceeding.

b. A stipulation that the applicant shall agree that the sale, assignment in fact or law, or such other transfer of applicant's financial interest in the PV SOLAR FARM shall in no way affect or change applicant's obligation to continue to comply with the terms of this plan. Any successor in interest, assignee, and all parties to the decommissioning and site reclamation plan shall assume the terms, covenants, and obligations of this plan and agrees to assume all reclamation liability and responsibility for the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF).

c. Authorization for the GOVERNING BODY and its authorized representatives for right of entry onto the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) premises for the purpose of inspecting the methods of reclamation or for performing actual reclamation if necessary.

d. A stipulation that at such time as decommissioning takes place the applicant, its successors in interest, and all parties to the decommissioning and site reclamation plan are required to enter into a Roadway Use and Repair Agreement with the relevant highway authority.

e. A stipulation that the Applicant, its successors in interest, and all parties to the decommissioning and site reclamation plan shall provide evidence of any new, additional, or substitute financing or security agreement to the Zoning Administrator throughout the operating lifetime of the project.

f. A stipulation that the Applicant, its successors in interest, and all parties to the decommissioning and site reclamation plan shall be obliged to perform the work in the decommissioning and site reclamation plan before abandoning the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) or prior to ceasing production of electricity from the CDSF, after it has begun, other than in the ordinary course of business. This obligation shall be independent of the obligation to pay financial assurance and shall not be limited by the amount of financial assurance. The obligation to perform the reclamation work shall constitute a covenant running with the land.

g. The decommissioning and site reclamation plan shall provide for payment of any associated costs that Champaign County may incur in the event that decommissioning is actually required. Associated costs include all administrative and ancillary costs associated with drawing upon the financial assurance and performing the reclamation work and shall include but not be limited to attorney's fees; construction management and other professional service fees; and the costs of preparing requests for proposals and bidding documents required to comply with state law or Champaign County purchasing policies.

h. The depth of removal of foundation concrete below ground shall be a minimum of 54 inches. The depth of removal of foundation concrete shall be certified in writing by an Illinois Licensed Professional Geologist or Engineer and the certification shall be submitted to the Zoning Administrator.

i. Underground electrical cables at a depth of 5 feet or greater may be left in place.

j. The hole resulting from the removal of foundation concrete during decommissioning shall be backfilled as follows:

(a) The excavation resulting from the removal of foundation concrete shall only be backfilled with subsoil and topsoil in similar depths and similar types as existed at the time of the original CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) construction except that a lesser quality topsoil or a combination of a lesser quality topsoil and a subsoil that is similar to the native subsoil may be used at depths corresponding to the native subsoil but not less than 12 inches below grade.

(b) The native soils excavated at the time of the original CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) construction may be used to backfill the concrete foundation excavations at the time of decommissioning provided that the soils are adequately stored throughout the operating lifetime of the CDSF. The methods for storing the excavated native soils during the operating lifetime of the CDSF shall be included in the decommissioning and site reclamation plan.

(c) If the excavated native soils are not stored for use for backfilling the concrete foundation excavations, a qualified soil scientist or Illinois Licensed Professional Geologist or Engineer shall certify that the actual soils used to backfill the concrete foundation excavations are of equal or greater quality than the native soils or that, in the case of subsoil, the backfill soil meets the requirements of this paragraph. The certification shall be submitted to the Zoning Administrator.

(d) An Illinois Licensed Professional Geologist or Engineer shall certify in writing that the concrete foundation excavations have been backfilled with soil to such a depth and with a minimum of compaction that is consistent with the restoration of productive agricultural use such that the depth of soil is expected to be no less than 54 inches within one year after backfilling.

k. A stipulation that should the decommissioning and site reclamation plan be deemed invalid by a court of competent jurisdiction the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) SPECIAL USE permit shall be deemed void.

l. A stipulation that the Applicant’s obligation to complete the decommissioning and site reclamation plan and to pay all associated costs shall be independent of the Applicant’s obligation to provide financial assurance.

m. A stipulation that the liability of the Applicant's failure to complete the decommissioning and site reclamation plan or any breach of the decommissioning and site reclamation plan requirement shall not be capped by the amount of the financial assurance.

n. If the Applicant desires to remove equipment or property credited to the estimated salvage value without the concurrent replacement of the property with property of equal or greater salvage value, or if the Applicant installs equipment or property increasing the cost of decommissioning after the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) begins to produce electricity, at any point, the Applicant shall first obtain the consent of the Zoning Administrator. If the Applicant's lien holders remove equipment or property credited to the salvage value, the Applicant shall promptly notify the Zoning Administrator. In either of these events, the total financial assurance shall be adjusted to reflect any change in total salvage value and total decommissioning costs resulting from any such removal or installation.

(4) To comply with paragraph 6.1.1 A.5., the Applicant shall provide financial assurance in the form of an irrevocable letter of credit as follows:

a. At the time of Special Use Permit approval, the amount of financial assurance to be provided for the decommissioning and site reclamation plan shall be 125% of the decommissioning cost as determined in the independent professional geologist or, engineer's cost estimate to complete the decommissioning work described in Sections 6.1.1 A.4.a. and 6.1.1 A.4.b. and 6.1.1 A.4.c. and shall otherwise be compliant with Section 6.1.1.A.5. except that if the SOLAR PV modules have an unlimited warranty of at least 10 years and also have a limited power warranty to provide not less than 80% nominal power output up to 25 years and proof of that warranty is provided at the time of Zoning Use Permit approval, financial assurance may be provided for the decommissioning and site reclamation plan as follows:

(a) No Zoning Use Permit to authorize construction of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) shall be authorized by the Zoning Administrator until the CDSF owner shall provide the County with Financial Assurance to cover 12.5% of the decommissioning cost as determined in the independent geologist or engineer's cost estimate to complete the decommissioning work described in Sections 6.1.1 A.4.a. and 6.1.1 A.4.b. and 6.1.1 A.4.c. and otherwise compliant with Section 6.1.1 A.5.

(b) On or before the sixth anniversary of the Commercial Operation Date, the CARBON DIOXIDE SEQUESTRATION FACILITY

(CDSF) Owner shall provide the County with Financial Assurance to cover 62.5% of the decommissioning cost as determined in the independent geologist or engineer's cost estimate to complete the decommissioning work described in Sections 6.1.1 A.4.a. and 6.1.1 A.4.b. and 6.1.1 A.4.c. and otherwise compliant with Section 6.1.1 A.5.

(c) On or before the eleventh anniversary of the Commercial Operation Date, the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) owner shall provide the County with Financial Assurance to cover 125% of the decommissioning cost as determined in the independent geologist or engineer's cost estimate to complete the decommissioning work described in Sections 6.1.1 A.4.a. and 6.1.1 A.4.b. and 6.1.1 A.4.c. and otherwise compliant with Section 6.1.1 A.5.

b. Net salvage value may be deducted from decommissioning costs as follows:

(a) One of the following standards shall be met:

i. The Applicant, its successors in interest, and all parties to the decommissioning and site reclamation plan shall maintain the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) free and clear of liens and encumbrances, including financing liens and shall provide proof of the same prior to issuance of the SPECIAL USE Permit; or

ii. The Applicant, its successors in interest, and all parties to the decommissioning and site reclamation plan shall deduct from the salvage value credit the amount of any lien or encumbrance on the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF); or

iii. Any and all financing and/or financial security agreements entered into by the Applicant, its successors in interest, and all parties to the decommissioning and site reclamation plan shall expressly provide that the agreements are subject to the covenant required by Section 6.1.1 A.2 that the reclamation work be done.

(b) The Applicant, its successors in interest, and all parties to the decommissioning and site reclamation plan shall provide proof of compliance with paragraph 6.1.7. R.(4)b.(a) prior to issuance of any Zoning Use Permit and upon every renewal of the financial assurance and at any other time upon the request of the Zoning Administrator.

(c) The Applicant, its successors in interest, and all parties to the decommissioning and site reclamation plan shall provide in the decommissioning and site reclamation plan for legal transfer of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) to the demolisher to pay the costs of reclamation work, should the reclamation work be performed.

(d) The net estimated salvage value that is deducted from the estimated decommissioning costs shall be the salvage value that results after all related costs for demolition and any required preparation for transportation for reuse or recycling or for simple disposal and other similar costs including but not limited to the decommissioning of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) STRUCTURES, equipment, and access roads.

(e) Estimated salvage value shall be based on the average salvage price of the past five years as published in a reputable source for salvage values and shall reflect sound licensed professional judgment as to anticipated changes in salvage prices prior to the next update of estimated net salvage value.

(f) The deduction from the estimated decommissioning costs for net estimated salvage value shall be capped at 70% of the total net estimated salvage value even though the total actual salvage value shall be available in the event that decommissioning is actually required.

(g) The total financial assurance after deduction of the net estimated salvage value shall not be less than $1,000 per acre.

(h) The credit for net estimated salvage value attributable to any CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) may not exceed the estimated cost of removal of the above-ground portion of that CDSF on the subject site.

c. The GOVERNING BODY has the right to require multiple letters of credit based on the regulations governing federal insurance for deposits.

d. The Applicant, its successors in interest, and all parties to the decommissioning and site reclamation plan shall adjust the amount of the financial assurance to ensure that it reflects current and accurate information as follows:

(a) At least once every three years for the first 12 years of the financial assurance and at least once every two years thereafter or, if the SOLAR PV modules have an unlimited warranty of at least 10 years and also have a limited power warranty to provide not less not than 80% nominal power output up to 25 years and proof of that warranty is provided at the time of Zoning Use Permit approval, then at least once every five years for the first 25 years of the financial assurance and at least once every two years thereafter, the Applicant, its successors in interest, and all parties to the decommissioning and site reclamation plan shall use an independent Illinois Licensed Professional Geologist or Engineer to provide updated estimates of decommissioning costs and salvage value, by including any changes due to inflation and/or change in salvage price. The Applicant, its successors in interest, and all parties to the decommissioning and site reclamation plan shall, upon receipt, provide a copy of the adjusted Professional Engineer's report to the Zoning Administrator.

(b) At all times, the value of the irrevocable letter of credit shall equal or exceed the amount of the independent geologist or engineer's cost estimate as increased by known and documented rates of inflation based on the Consumer Price Index since the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) was approved.

e. The long term corporate debt (credit) rating of the letter of credit issuing financial institution by both Standard & Poor's Financial Services LLC (S&P) and Moody's Investors Service (Moody's) shall be equal to or greater than the minimum acceptable long term corporate debt (credit) rating, as follows:

(a) The Zoning Administrator shall verify the long term corporate debt (credit) rating of the proposed financial institution by both Standard & Poor's Financial Services LLC (S&P) and Moody's Investors Service (Moody's).

(b) The minimum acceptable long term corporate debt (credit) rating of the proposed financial institution shall be a rating of "A" by S&P or a rating of "A2" by Moody's.

(c) Whenever the most current long term corporate debt (credit) rating of the proposed financial institution by either S&P or Moody's is lower than the minimum acceptable long term corporate debt (credit) rating, the letter of credit shall be replaced with a new irrevocable letter of credit from an issuing financial institution whose most current long term corporate debt (credit) rating by either S&P or Moody's meets or exceeds the minimum acceptable long term corporate debt (credit) rating,

f. At all times the value of the irrevocable letter of credit shall be increased annually as necessary to reflect actual rates of inflation over the life span of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) and the amount shall be equal to or exceed 125% of the amount of the independent geologist or engineer's cost estimate as increased by known and documented rates of inflation since the CDSF was approved.

g. Should the salvage value of components be adjusted downward or the decommissioning costs adjusted upward pursuant to paragraph 6.1.7 R.(4)d., the amount of the irrevocable letter of credit pursuant to this paragraph 6.1.5 Q.(4) shall be increased to reflect the adjustment, as if the adjusted estimate were the initial estimate.

h. Unless the Governing Body approves otherwise, the Champaign County State's Attorney's Office shall review and approve every Letter of Credit prior to acceptance by the Zoning Administrator.

(5) In addition to the conditions listed in subparagraph 6.1.1 A.9. the Zoning Administrator may also draw on the funds for the following reasons:

a. In the event that any CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) or component thereof ceases to be functional for more than six consecutive months after it starts producing electricity and the Owner is not diligently repairing such CDSF or component of the CDSF.

b. In the event that the Owner declares the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) or any CDSF component to be functionally obsolete for tax purposes.

c. There is a delay in the construction of any CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) of more than 6 months after construction on that CDSF begins.

d. Any CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) or component thereof that appears in a state of disrepair or imminent collapse and/or creates an imminent threat to the health or safety of the public or any person.

e. Any CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) or component thereof that is otherwise derelict for a period of 6 months.

f. The CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) is in violation of the terms of the CDSF FARM SPECIAL USE permit for a period exceeding ninety (90) days.

g. The Applicant, its successors in interest, and all parties to the decommissioning and site reclamation plan has failed to maintain financial assurance in the form and amount required by the special use permit or compromised the COUNTY's interest in the decommissioning and site reclamation plan.

h. The COUNTY discovers any material misstatement of fact or misleading omission of fact made by the Applicant in the course of the special use permit zoning case.

i. The Applicant has either failed to receive a copy of the certification of design compliance required by paragraph 6.1.5 D. or failed to submit it to the County within 12 consecutive months of receiving a Zoning Use Permit regardless of the efforts of the Applicant to obtain such certification.

(6) The Zoning Administrator may, but is not required to, deem the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) abandoned, or the standards set forth in Section 6.1.7 R.(5) met, with respect to some, but not all, of the CDSF. In that event, the Zoning Administrator may draw upon the financial assurance to perform the reclamation work as to that portion of the CDSF only. Upon completion of that reclamation work, the salvage value and reclamation costs shall be recalculated as to the remaining CDSF.

(7) The Decommissioning and Site Reclamation Plan shall be included as a condition of approval by the BOARD and the signed and executed irrevocable letter of credit and evidence of the escrow account must be submitted to the Zoning Administrator prior to any Zoning Use Permit approval.

S. Complaint Hotline

(1) Prior to the commencement of construction on the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) and during the entire term of the County Board SPECIAL USE permit and any extension, the Applicant and Owner shall establish a telephone number hotline for the general public to call with any complaints or questions.

(2) The telephone number hotline shall be publicized and posted at the operations and maintenance center and the construction marshalling yard.

(3) The telephone number hotline shall be manned during usual business hours and shall be an answering recording service during other hours.

(4) Each complaint call to the telephone number hotline shall be logged and identify the name and address of the caller and the reason for the call.

(5) All calls shall be recorded and the recording shall be saved for transcription for a minimum of two years.

(6) A copy of the telephone number hotline calls shall be provided to the Zoning Administrator on a monthly basis.

(7) The Applicant and Owner shall take necessary actions to resolve all legitimate complaints.

T. Standard Condition for Expiration of CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) County Board SPECIAL USE Permit

A CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) County Board SPECIAL USE Permit designation shall expire in 10 years if no Zoning Use Permit is granted.

U. Application Requirements

(1) In addition to all other information required on the SPECIAL USE Permit application and required by Section 9.1.11 A.2., the application shall contain or be accompanied by the following information:

a. A CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) Project Summary, including, to the extent available:

(a) A general description of the project including any proposed new CDSF or proposed modifications to an existing CDSF that identifies all structures and equipment to be installed including the location and number of injection and monitoring wells, compressors, pipelines, and facility water and electrical demands.

(b) Identification of the applicant, owner(s) and operator(s) of the CDSF including their name(s), address(es), phone number(s) and email addresses and the names(s), owner(s), address(es), phone numbers and email addresses of all businesses owned and/or properties owned that would be associated with the CDSF.

(c) The names, addresses, and phone numbers of all property owners of any part of the CDSF, including the AOR and the sequestration field.

(d) The specific proposed location of the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) including all tax parcels on which pore space will be used by the CDSF.

(e) The specific proposed location of all tax parcels required to be included in the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) County Board SPECIAL USE Permit.

(f) A description of the Applicant; Owner and Operator, including their respective business structures.

(g) Identifies proposed suppliers and identifies electricity, natural gas, water, and other physical material and energy demands; facility maintenance plans; facility emergency response plan; facility expansion potential, and facility decommissioning plan and costs.

(h) A description of the proposed CARBON DIOXIDE PLUME (PLUME) location in sufficient detail to document that the PLUME shall not be over, penetrate through, or store carbon dioxide under a PRIMARY SAND AND GRAVEL AQUIFER.

(i) Provides an estimate of the projected average annual and average daily gross volume of carbon dioxide proposed to be injected by the CDSF and the number of years the project will be in operation.

(j) Describes where and how captured carbon dioxide will be transported to the CDSF, including information related to any proposed or existing CDCF or CDP that would capture or transport the carbon dioxide.

(k) Confirms that the applicant has applied for the following:

i. Class VI well permit from either the U.S. EPA or the State of Illinois; and

ii. Carbon dioxide sequestration permit from the Illinois EPA.

b. A site plan and maps in printed and digital formats for the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) indicating the following:

(a) The approximate planned location of all CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) STRUCTURES, property lines (including identification of adjoining properties), required separations, public access roads and turnout locations, access driveways, electrical transformer(s), cabling, switching station, electrical cabling from the CDSF to the substations(s), ancillary equipment, screening and fencing, third party transmission lines, meteorological station, maintenance and management facilities, and layout of all structures within the geographical boundaries of any applicable setback.

(b) The site plan shall clearly indicate the area of the proposed CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) County Board SPECIAL USE Permit as required by subparagraph 6.1.5 A.(1).

(c) The location of all below-ground wiring, utilities, and foundations installed or constructed during the duration of the project.

(d) The location, height, and appearance of all above-ground wiring and wiring structures.

(e) The separation of all CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) structures from adjacent DWELLINGS and/or PRINCIPAL BUILDINGS or uses shall be dimensioned on the approved site plan and that dimension shall establish the effective minimum separation that shall be required for any Zoning Use Permit. Greater separation and somewhat different locations may be provided in the approved site plan for the Zoning Use Permit provided that that the greater separation does not increase the noise impacts and/or glare that were approved in the CDSF County Board SPECIAL USE Permit. CDSF structures includes substations, third party transmission lines, maintenance and management facilities, or other significant structures.

c. A map of the AREA OF REVIEW (AOR) at a scale sufficient to depict:

(a) All municipal and county boundaries;

(b) Boundaries of PRIMARY SAND AND GRAVEL AQUIFERS;

(c) All STREETS;

(d) The proposed location of each injection, monitoring, or groundwater monitoring well;

(e) The extent of the underground carbon dioxide PLUME associated with each injection well, as modeled by the applicant and submitted to and approved by the U.S. EPA;

(f) The extent of the underground pressure plume associated with each injection well beyond the extent of the underground carbon dioxide PLUME;

(g) Abandoned and monitoring wells that might facilitate a leak of carbon dioxide to the ground surface;

(h) Active oil, gas, wastewater, water wells and any other active well not identified in this section;

(i) PRINCIPAL STRUCTURES, livestock operations, and OUTDOOR GATHERING SPACE(S).

d. Documentation of the determination of no MAJOR SAND AND GRAVEL AQUIFERS over or under the CDSF including the review of existing well records, the review of maps of known aquifers, and the results of aquifer pumping tests.

e. Information about seismic activity within the AOR and the potential for inducing earthquakes shall be provided, including:

(a) Seismic history, including a detailed record of historical and recent seismic activity within the AOR that specifies date, magnitude, frequency, and location of natural earthquakes, if any;

(b) Geologic fault characterization, including detailed mapping of any known geologic structures including faults and geologic folds within the AOR; the proximity of geologic faults or geologic folds to the proposed injection wells; and the assessment of potential for reactivation; and

(c) An assessment of potential fault reactivation or fractures of the cap rock due to CO2 injection.

f. All other required studies, reports, certifications, and approvals demonstrating compliance with the provisions of this Ordinance in printed and digital formats.

g. The CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) SPECIAL USE permit application shall include documentation that the applicant has provided a complete copy of the SPECIAL USE permit application to any municipality and County Recorder within one-and-one-half miles of the proposed CDSF as required by Section 6.1.5 B.(2)a.(b).

h. A municipal resolution regarding the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) by any municipality located within one-and-one-half miles of the CDSF must be submitted to the ZONING ADMINISTRATOR prior to the consideration of the CDSF SPECIAL USE permit by the Champaign County Board or, in the absence of such a resolution, the ZONING ADMINISTRATOR shall provide documentation to the County Board that any municipality within one-and-one-half miles of the CDSF was provided notice of the meeting dates for consideration of the proposed CDSF SPECIAL USE Permit for both the Environment and Land Use Committee and the County Board as required by Section 6.1.5 B.(2)a.(c).

i. Documentation that the applicant and owner, and any parent companies of applicant and owners are financially sound and sufficiently experienced to complete the proposed CDSF or to modify the existing CDSF that is the subject of the application. Such documentation must include evidence of project financial viability; applicant, owner, and operator financial health including current financial reports; applicant's project development experience; applicant's and/or operator's experience managing and operating CDSF or similar industrial facilities; and applicant's fiscal capability to provide compensation, not including any financial assurance provided under Article XIV, FINANCIAL ASSURANCE, for possible damages caused by the CDSF including but not limited to damage to drinking water supplies, the impacts of a CDSF well blowout, CO2 release from CDSF surface facilities, or the release of CO2 to the atmosphere via third-party wells, natural faults, or other CO2 release routes.

j. An explanation of the commercial purposes of the CDSF or CDSF modifications, including documentation for claimed public benefits.

k. A description of all COUNTY, state, and federal statutes, regulations, ordinances, permits, codes, and standards applicable to the CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF).

l. Any other information normally required by the County as part of its Zoning Ordinance.

m. Any other information requested by the Zoning Administrator that may be useful in evaluating the potential environmental and socioeconomic impacts of the proposed CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) on Christian County residential, business, agricultural, livestock operations and any adjacent land uses.

(2) The Applicant shall submit at least ten paper copies of the SPECIAL USE Permit Application and one electronic copy in generally used formats.

(3) The Applicant shall notify the COUNTY of any changes to the information provided above that occurs while the County Board SPECIAL USE permit application is pending.

**9. Add the following paragraph 9.3.1 J. for Zoning Use Permit fee:**

K. CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF) .... $275 per ground surface acre of carbon dioxide PLUME

**10. Add new subsection 9.3.3 B.(9) as follows for Zoning Case Filing Fees:**

(9) CARBON DIOXIDE SEQUESTRATION FACILITY (CDSF)…………………..
Upon submission of the application, applicant shall submit a certified check to Champaign County in the amount of $250,000:

a. This amount shall be placed in a guaranteed money market account that will be used to cover the COUNTY'S costs, including but not limited to the costs of third party experts, geologists, landscape architects, land surveyors or engineers, and attorneys, that may be required pursuant to this Ordinance, during the special use application review process, public hearing(s) and any appeals or subsequent litigation.

b. Should the actual costs to the COUNTY exceed $250,000, the applicant shall be responsible for those costs. The COUNTY shall provide an accounting and invoice for such overage on a quarterly basis. The applicant shall remit additional funds within 30 days of invoice.

c. Any amount remaining in the account after the COUNTY renders its decision and all bills and invoices have been paid, shall be refunded to the applicant.

d. The applicant, owner, or operator shall reimburse the COUNTY for any and all reasonable fees for professional services incurred if the COUNTY, in its sole discretion, deems it necessary to hire an outside attorney, geologist, landscape architect, land surveyor or engineering consulting firm to work on any or all parts of the CDSF application process.