CarbonSAFE Illinois East Sub-Basin

Project Number DE-FE0029445

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U.S. Department of Energy

National Energy Technology Laboratory

Mastering the Subsurface Through Technology Innovation, Partnerships and Collaboration:
Carbon Storage and Oil and Natural Gas Technologies Review Meeting

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Presentation Outline

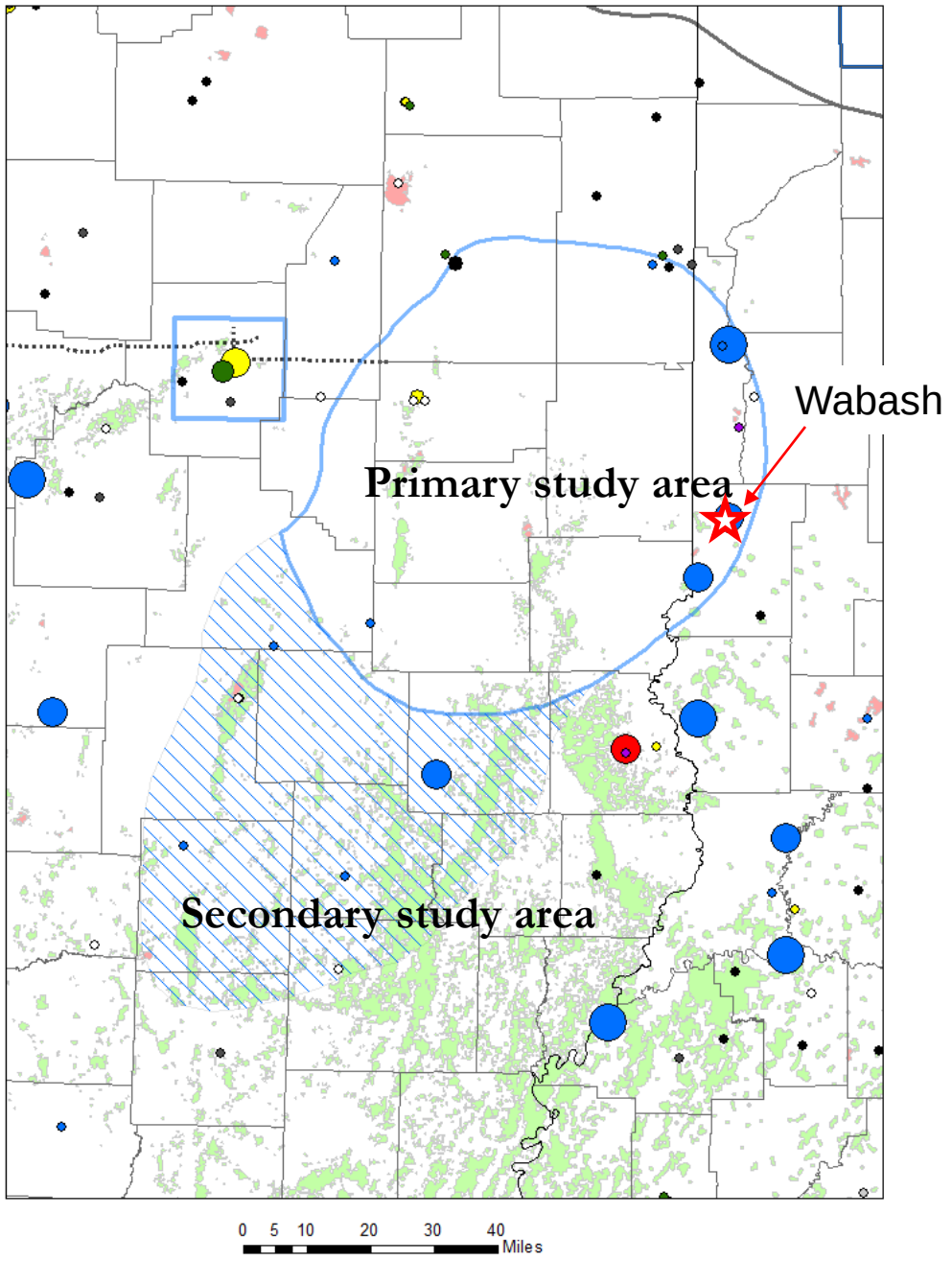
- Technical Status
- Accomplishments
- Lessons Learned
- Synergy Opportunities
- Project Summary

Technical Status

- A high-level technical evaluation of potential storage sites in the East sub-basin in Illinois is in progress.
- Evaluation includes subsurface characterization within the storage complex, risk identification, and an assessment of the potential industrial CO_2 source
- This project has led to the funding of the CarbonSAFE Wabash project.

Location of East Sub-Basin

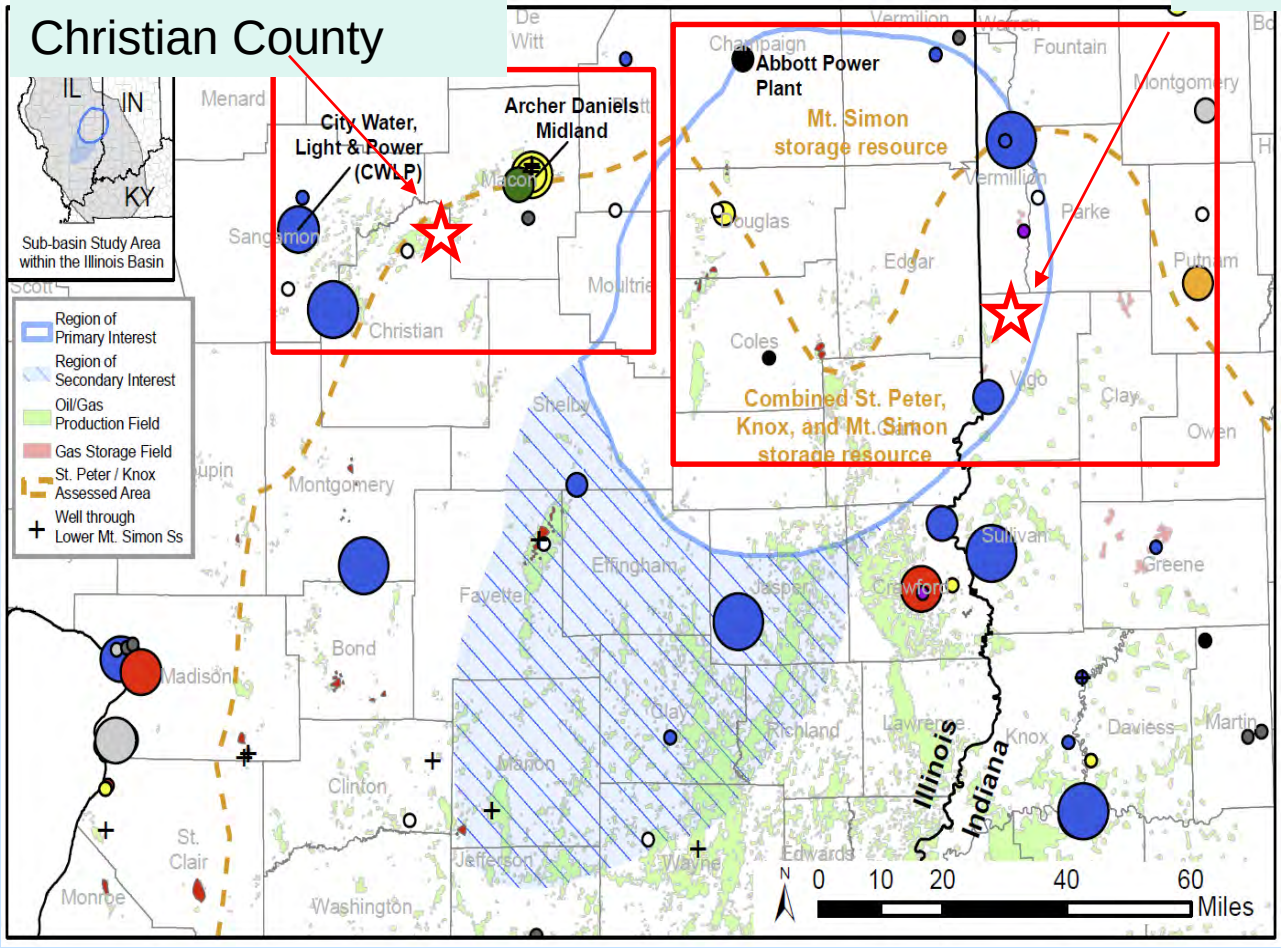
Work has been completed on primary study area with the start of the Feasibilty Wabash project



Location of East Sub-Basin

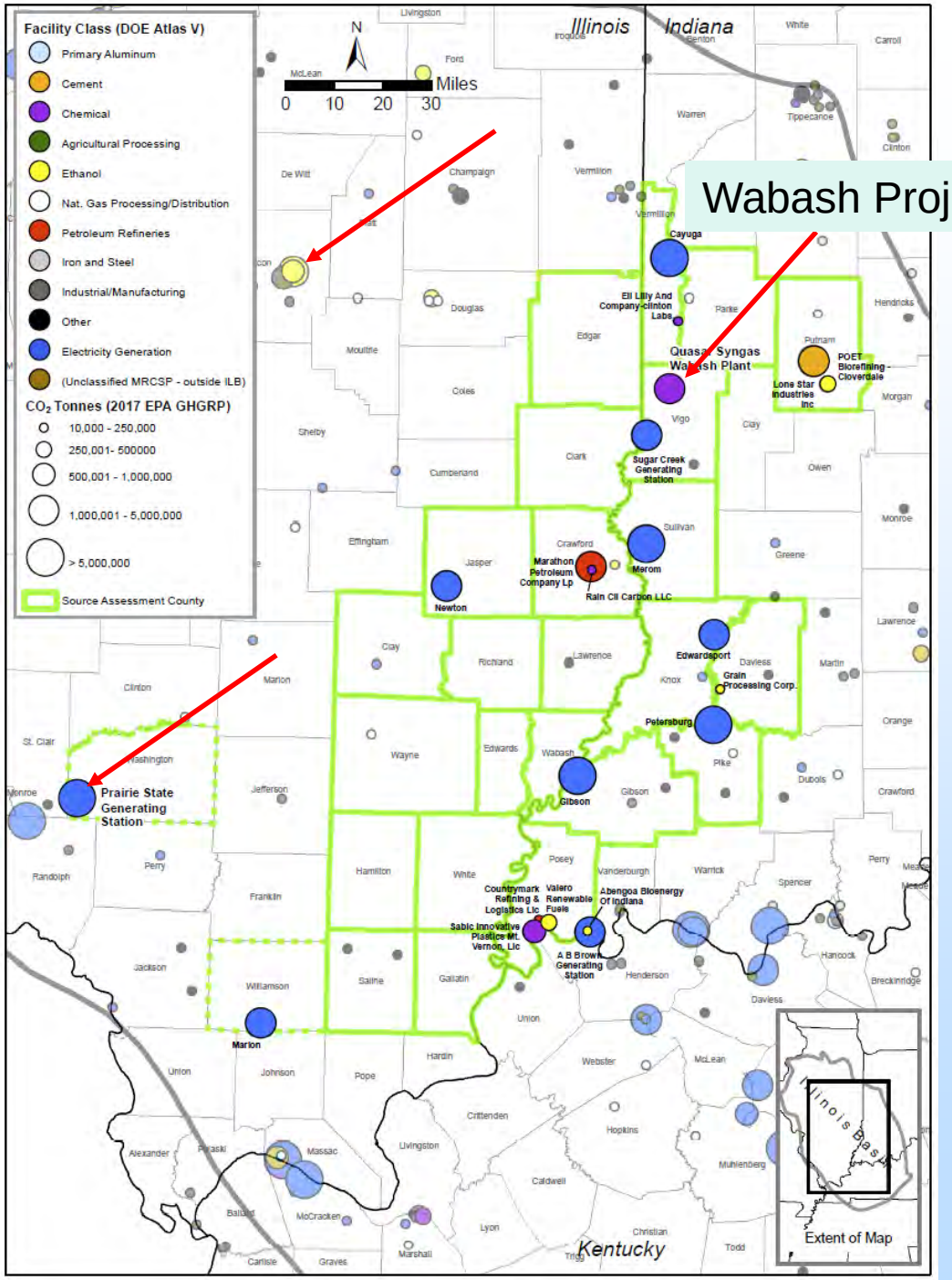
Feasibility Project
Macon
New Location in
Christian County

Wabash Project



MGSC CO_2 sources

- Primary Aluminum
- Cement
- Chemical
- Agricultural Processing
- Ethanol
- Nat. Gas Processing/Distribution
- Petroleum Refineries
- Iron and Steel
- Industrial/Manufacturing
- Electricity Generation
- Other

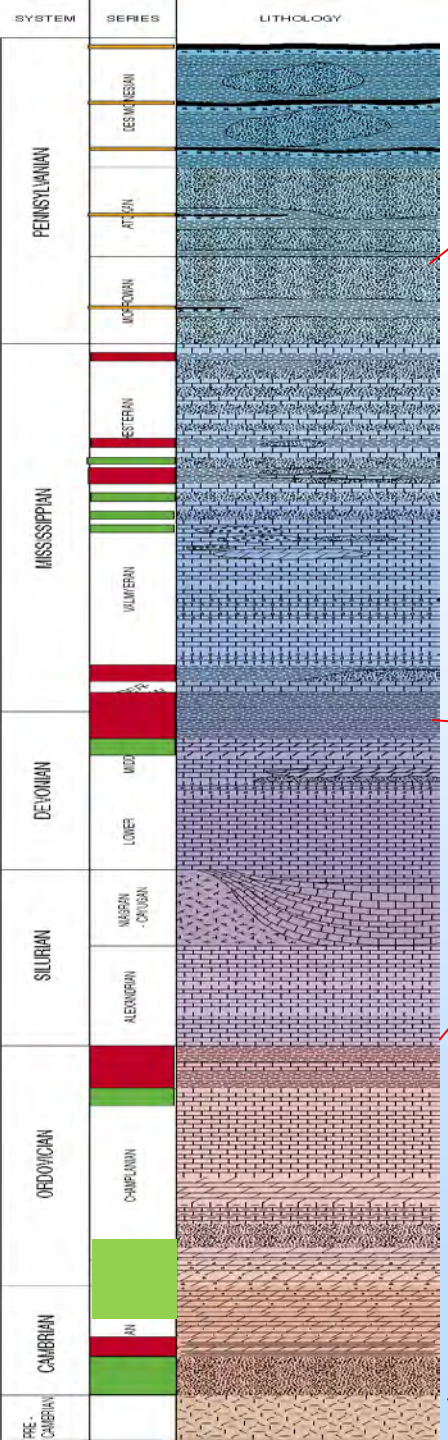


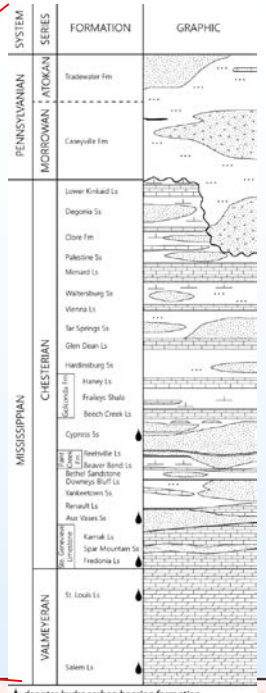
What is important in the southern part of East Basin

Large-scale anthropogenic CO_2 sources (>100,000 tonnes/year) considered in the East Sub-Basin project area

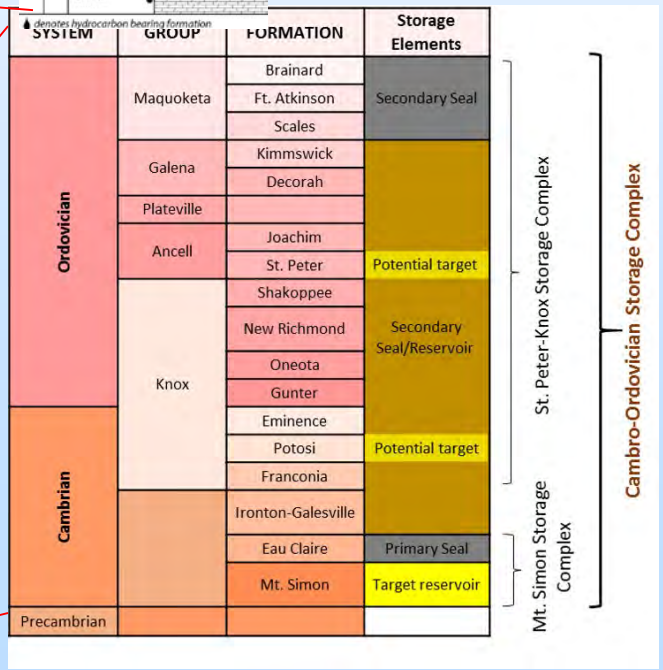
ID	Facility	Class	City	County	CO_2 Tonne	MW	Fuel	Company	Yr. of Build	Upgrade	Comment
1	Gibson Power Plant	Power Plant	Owensville	Gibson (IN)	13,350,951	3,145	Coal	Duke Energy	1971-1982		
	Secondary study area										
2	Prairie State Generating Station	Power Plant	Marissa	Washington	10,495,061	1,600	Coal	Cooperative	2012		Only plant in Illinois with supercritical boilers. Interested in CCS due to 45Q tax credits. CarbonSAFE visited facility for discussions. Expected early adopter.
3	Petersburg Power Plant	Power Plant	Petersburg	Pike (IN)	9,249,149	1,720	Coal/ Fuel Oil	Indianapolis Power & Light Company	1967-1986	1996-2004	Added FGD, SCR, low NOx burner -1996-2004
4	Merom Power Plant	Power Plant	Sullivan	Sullivan (IN)	5,082,733	1,070	Coal	Hoosier Energy	1976		
5	Cayuga Power Plant	Power Plant	Cayuga	Vermillion (IN)	5,045,932	1,104	Coal	Duke Energy	1967-1972	1993	Added Low NOx burner
6	Newton Power Plant	Power Plant	Newton	Jasper	4,794,893	615	Coal	Dynegy	1972-1975		One boiler retired in 2016
7	Edwardsport Power Plant	Power Plant	Edwardsport	Knox (IN)	2,653,783	618	Coal/ IGCC	Duke Energy	2013		Original unit built in 1918, retired in 2011
8	AB Brown Generating Station	Power Plant	Mt. Vernon	Posey (IN)	2,642,472	650	Coal/NG	Vectren	1979-2002		
9	Southern Illinois Power Coop	Power Plant	Marion	Williamson	2,323,167	433	Coal/NG	Cooperative	1963-1978	2003	
10	Marathon Petroleum	Refinery	Robinson	Crawford	1,697,277		Gas/Liquid		1906		
11	Sugar Creek Generating station	Power Plant	W. Terre Haute	Vigo (IN)	1,291,233	535	NG	Northern Indiana Public Service Company	2002-2003		
12	Lone Star Industries Inc.	Cement	Greencastle	Putnam (IN)	1,107,214		Coal/ Petcoke/Others	Buzzi Unicem USA	Kiln - 1966	2000	
13	SABIC Innovative Plastics, LLC	Petrochemicals	Mt. Vernon	Posey (IN)	661,148		NG	SABIC (Saudi Basic Industries Corpn)	1979-1996	2014	5 boilers, 2 coal boilers converted to NG in 2014
14	Countrymark Refining & Logistic	Refinery	Mt. Vernon	Posey (IN)	205,147		Refinery Fuel Gas		1950	2016	
15	Grain Processing Corpn	Ethanol	Washington	Daviess (IN)	209,246		NG/Biogas	Kent Corporation	2000	2015	Fermenter, dryer, boiler
16	Rain Cii Carbon LLC	Chemical	Robinson	Crawford	156,198		Greencoke		1998		Kiln. Calcined Pet Coke
17	Abengoa Biorefinery of Indiana	Ethanol	Mt. Vernon	Posey (IN)	151,574		NG	Green Plains, Inc.	2007		Fermenter, dryer, boiler
18	Eli Lilly & Co.	Chemical	Clinton	Vermillion (IN)	133,261		Coal/NG		1970-1976		
19	Valero Renewable Fuels	Ethanol	Mt. Vernon	Posey (IN)	139,838		NG		2008		Fermenter, dryer, boiler
20	POET Biorefinery - Cloverdale	Ethanol	Cloverdale	Putnam (IN)	132,877		NG		2008		Fermenter, dryer, boiler
	Primary study area										
21	Quasar Syngas, LLC - Wabash (in development)	Ammonia/Iron	W. Terre Haute	Vigo (IN)	1,570,000		Coal/ Petcoke				IGCC plant conversion in development, company interest in participation; Wabash CarbonSAFE feasibility proposal developed and submitted Feb. 2018 to DOE. Expected early adopter.
				Total CO_2 Tonnes, Annual	63,093,154						

Stratigraphy with Potential Seals and Sinks in the Illinois Basin





EOR potential



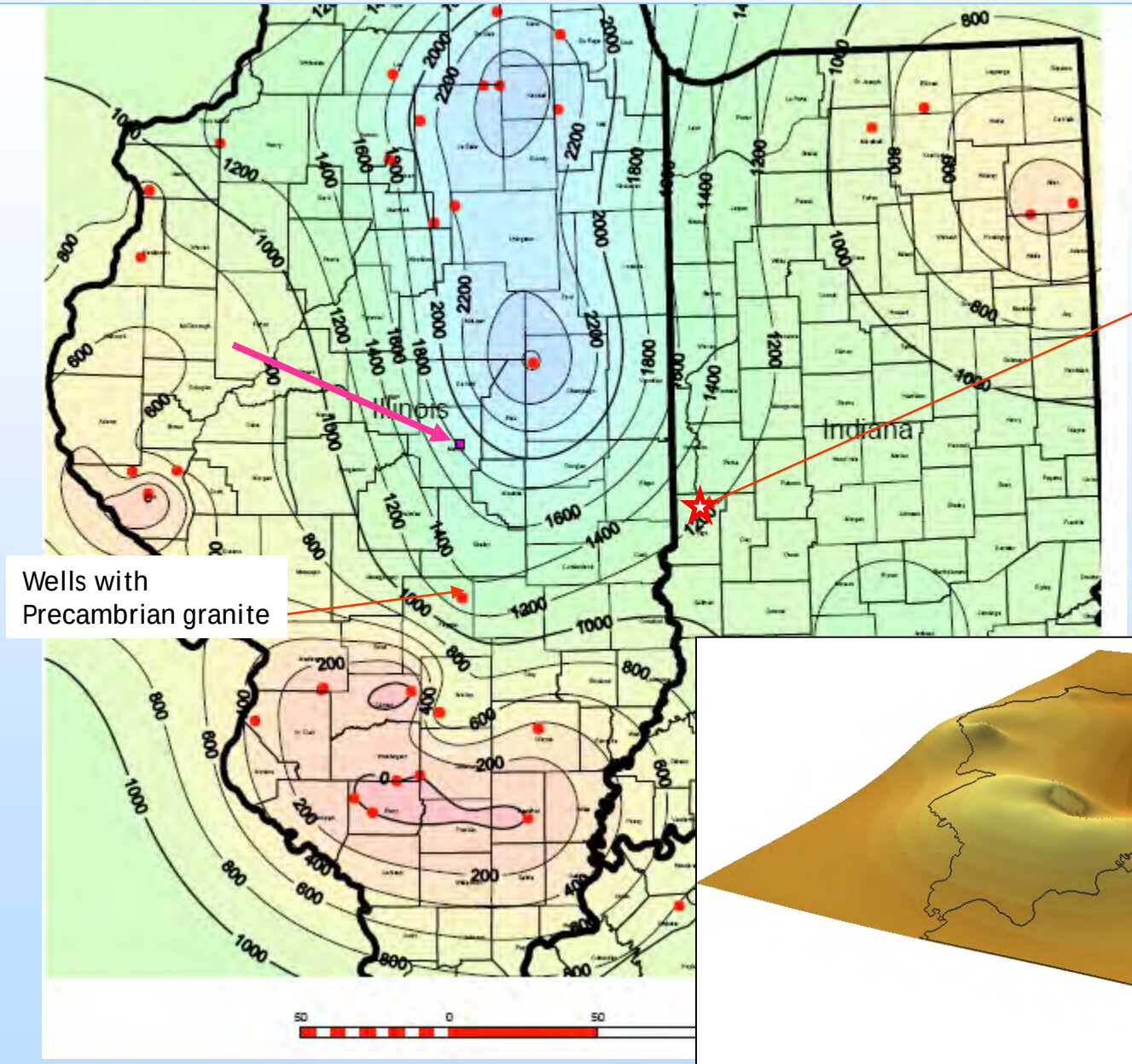
We have concentrated on the Ordovician and Cambrian

Potential Seal

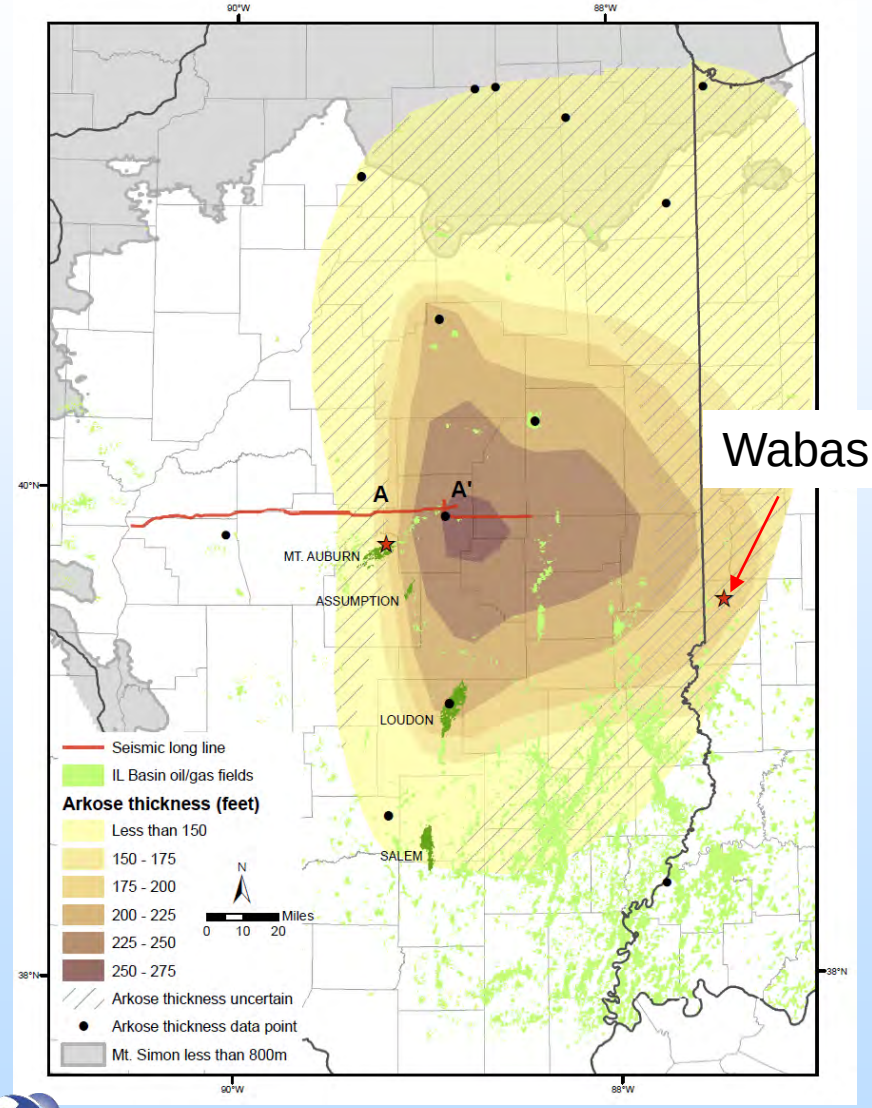
Potential Sink

Coal Bed Potential Sink and Seal

Thickness of the Mt. Simon Sandstone



“Arkosic storage play”

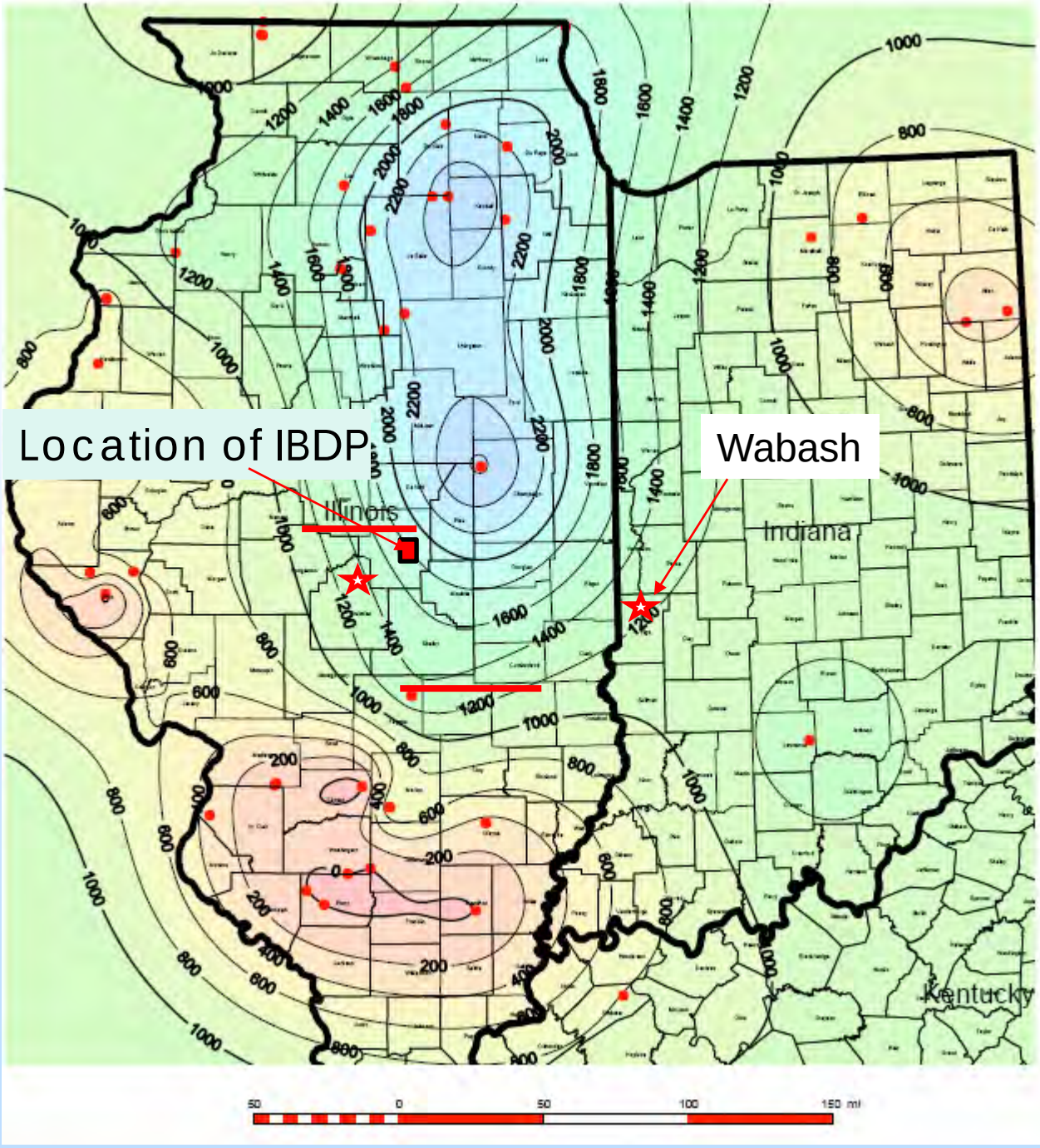


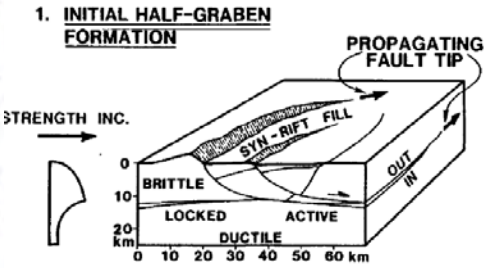
Wabash

Wabash Project would extend the lower Mt. Simon storage potential south and east

CarbonSAFE Illinois

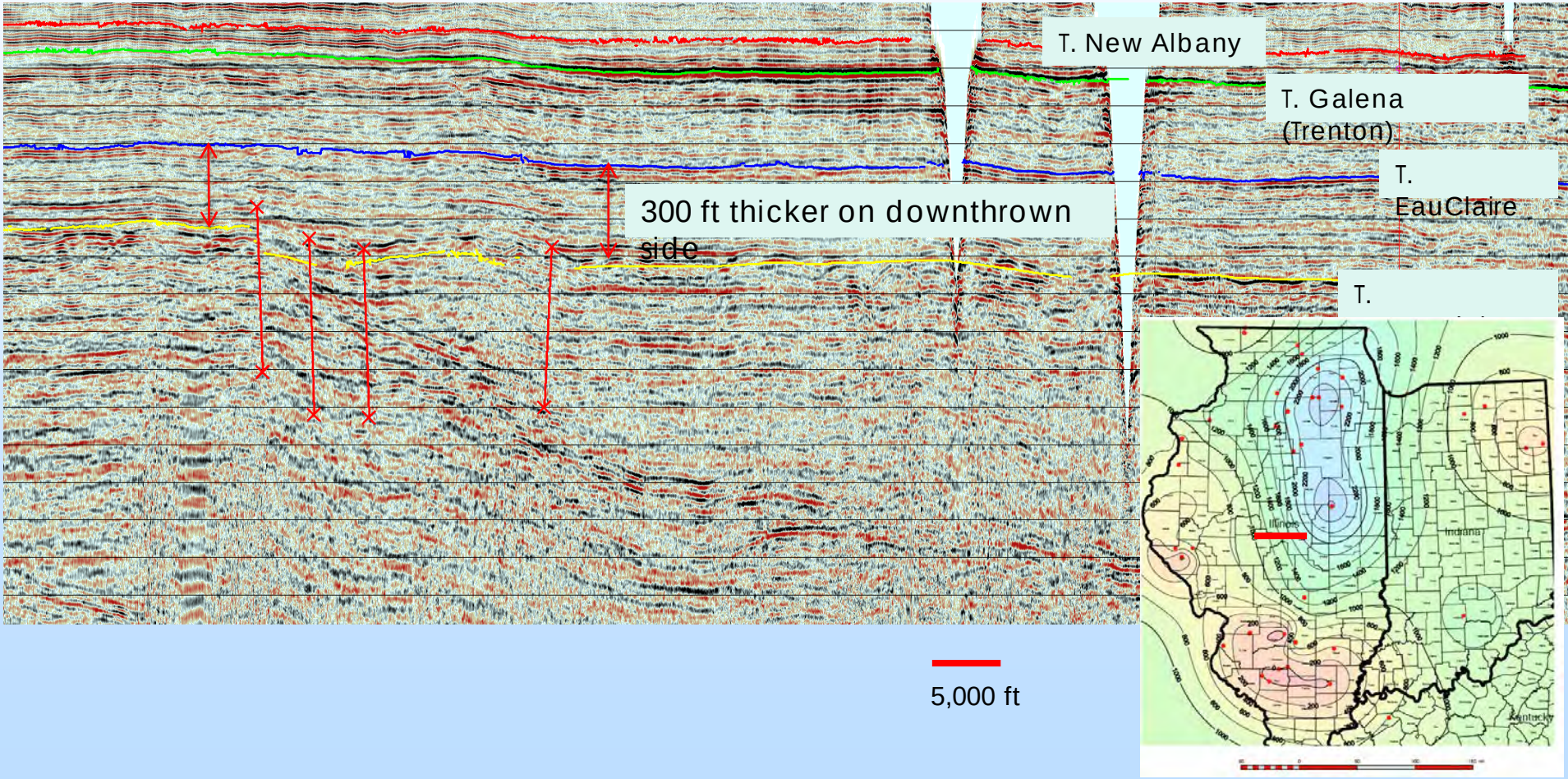
ILLINOIS STATE GEOLOGICAL SURVEY
PRAIRIE RESEARCH INSTITUTE





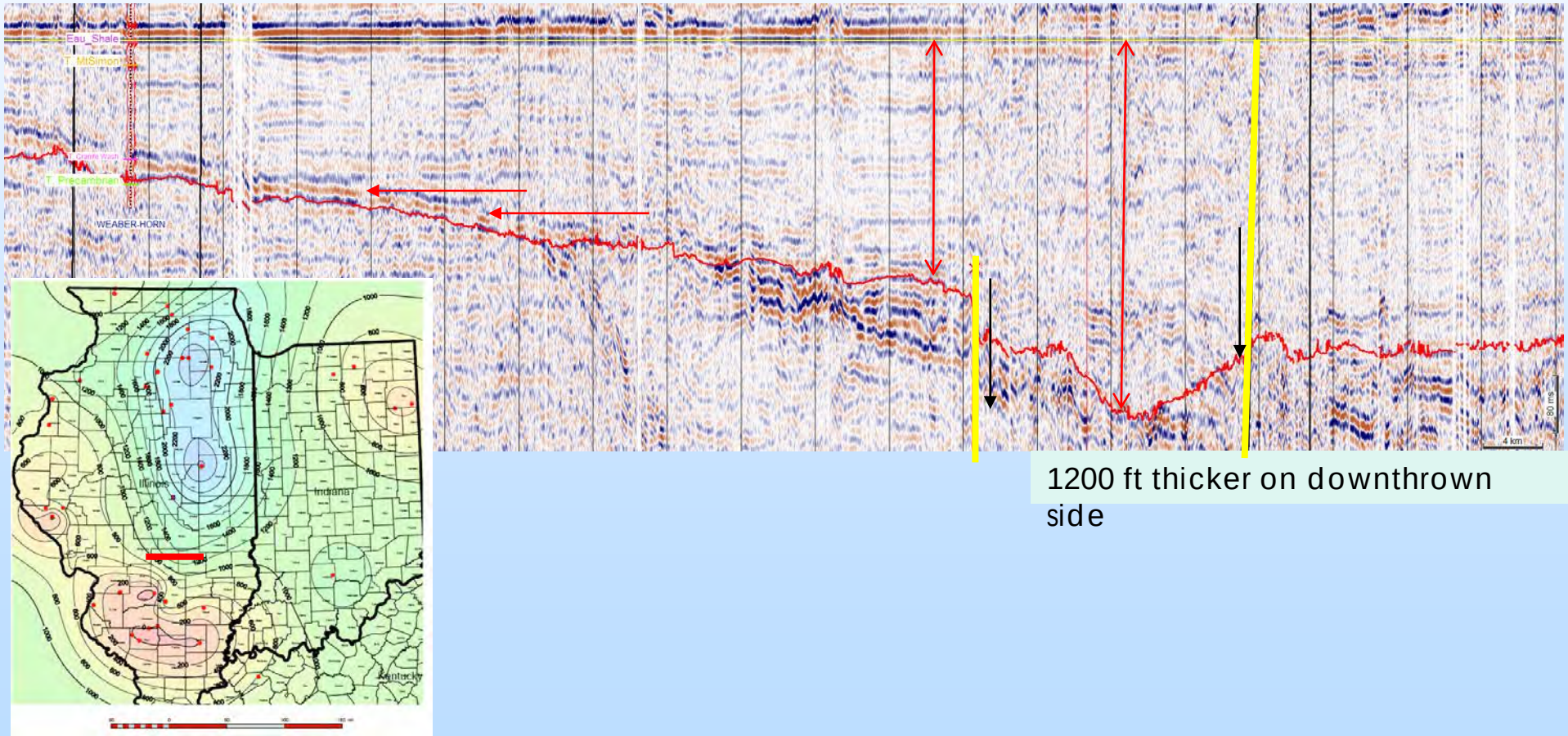
J.J. LAMBIASE & W. BOSWORTH, 1995

Growth Faults in the Precambrian



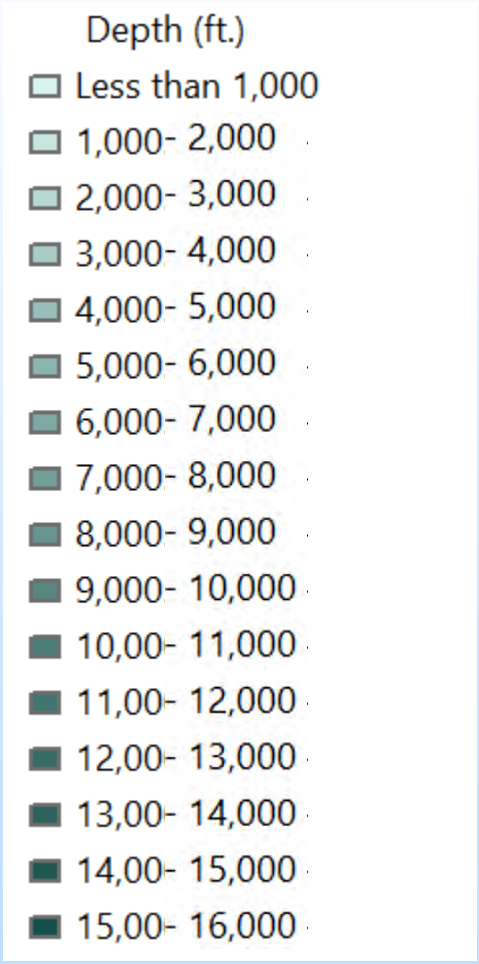
Growth Faults in the Precambrian

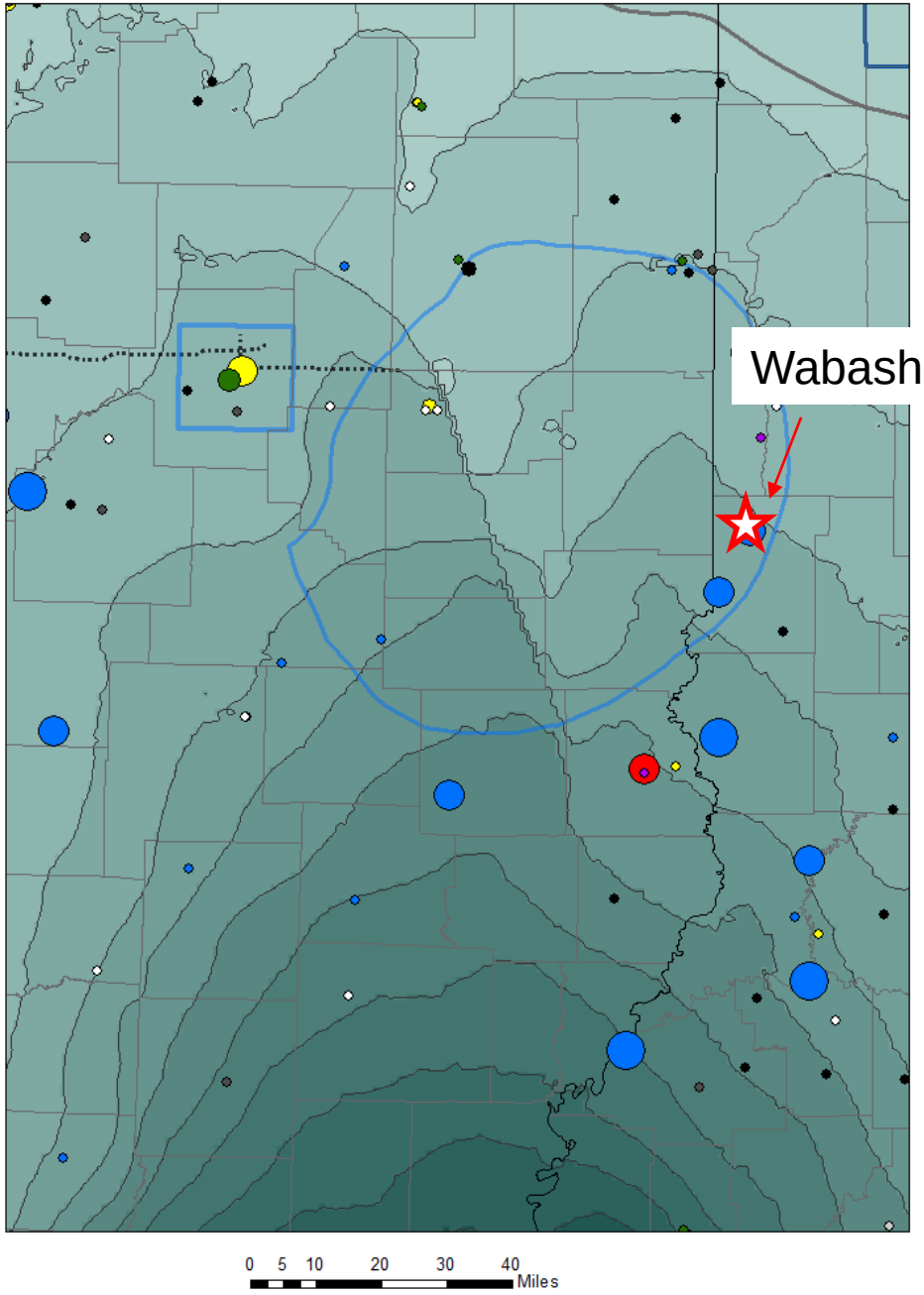
Weaber-Horn



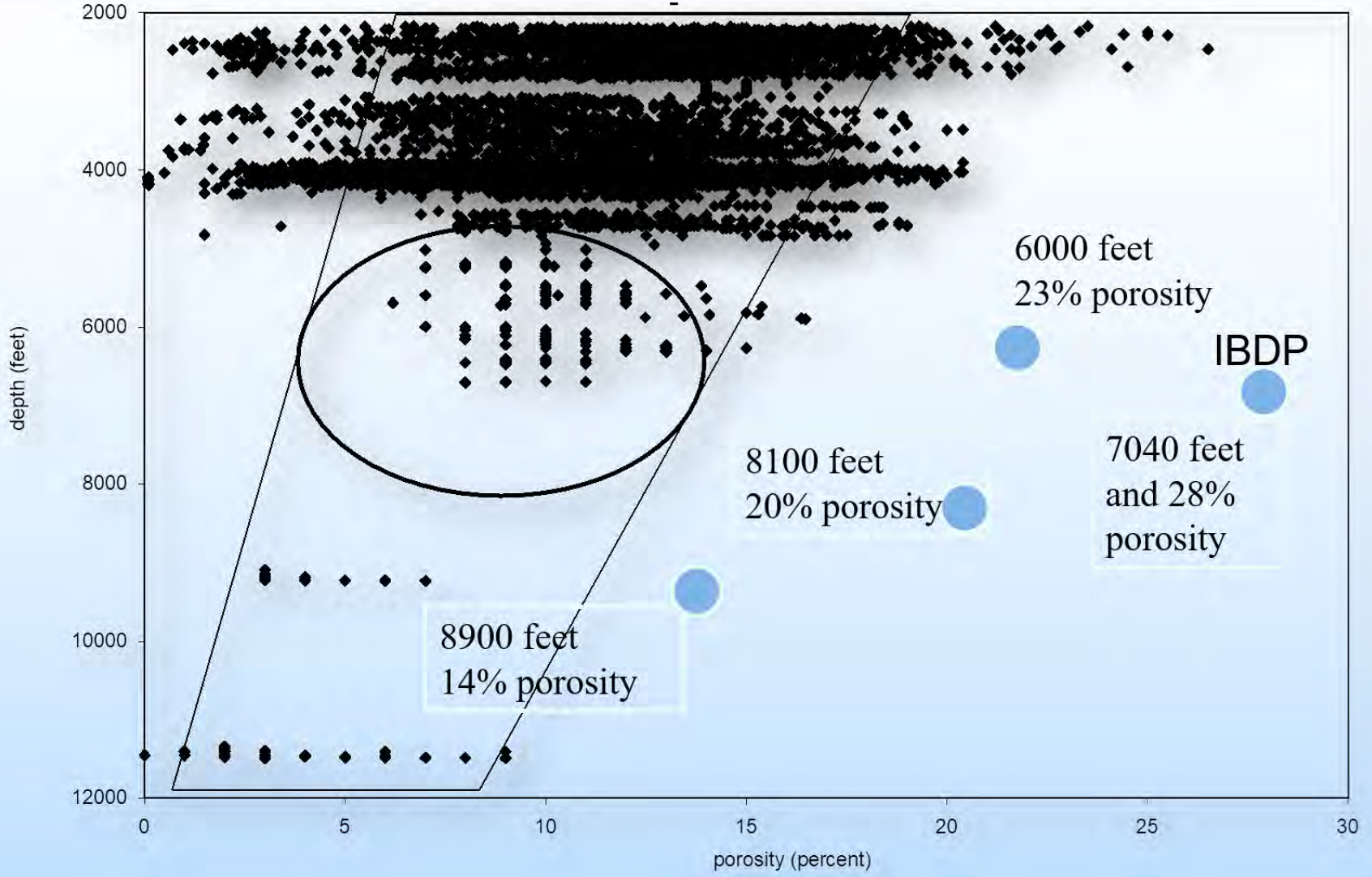
1200 ft thicker on downthrown side

Depth of the top of Mt. Simon Sandstone





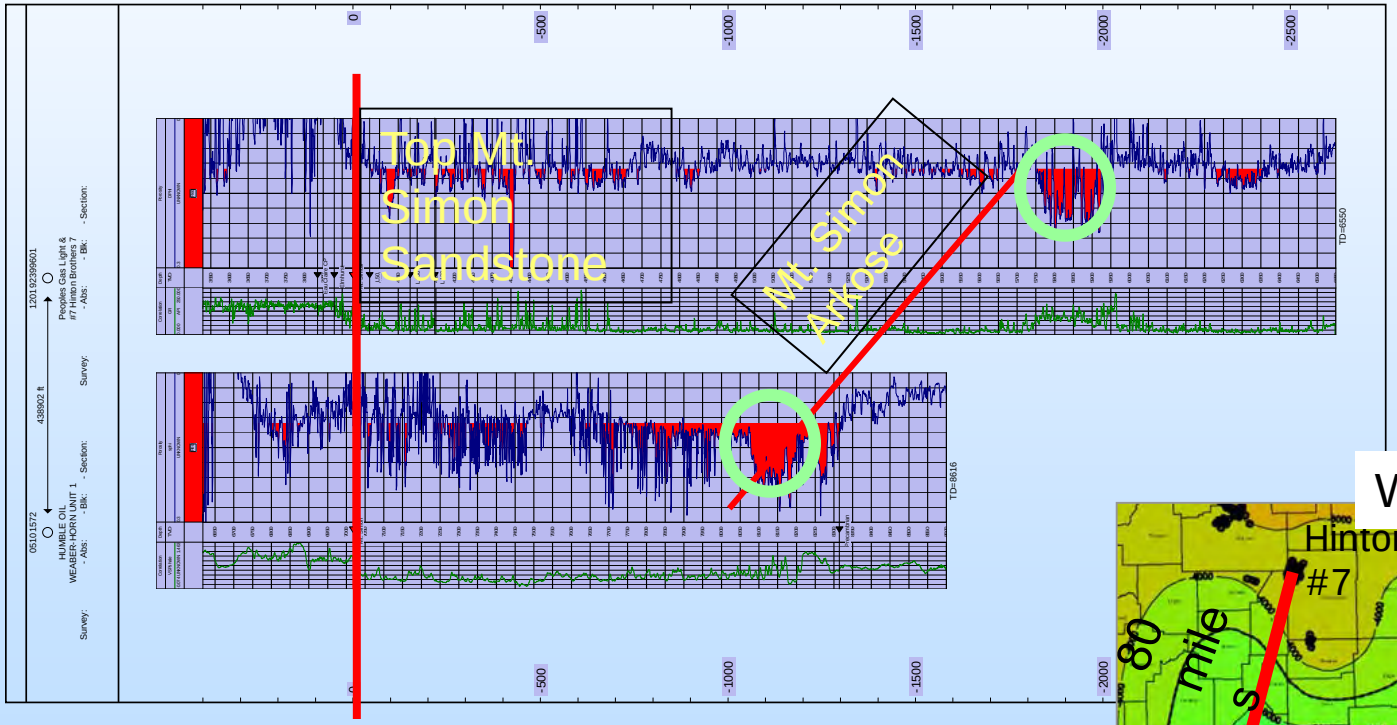
Porosity and its Relationship with Depth

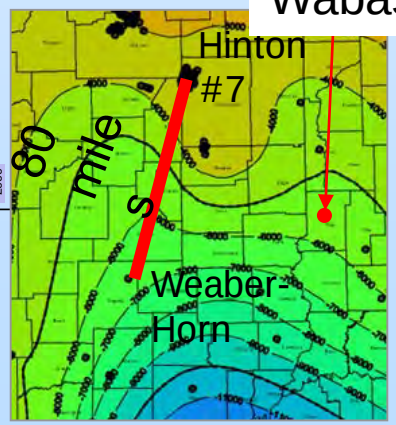


Comparison of Hinton #7 and Weaber-Horn

Hinton #7

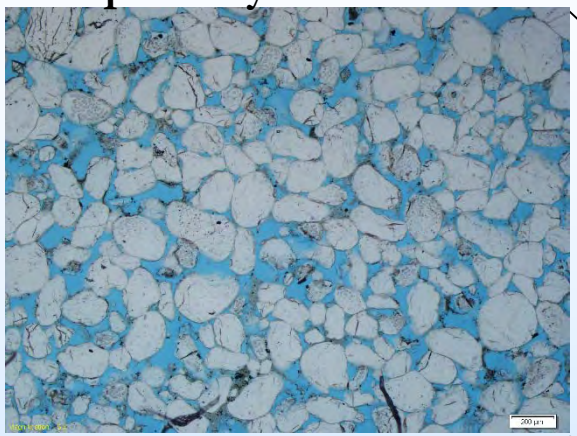
Weaber -Horn

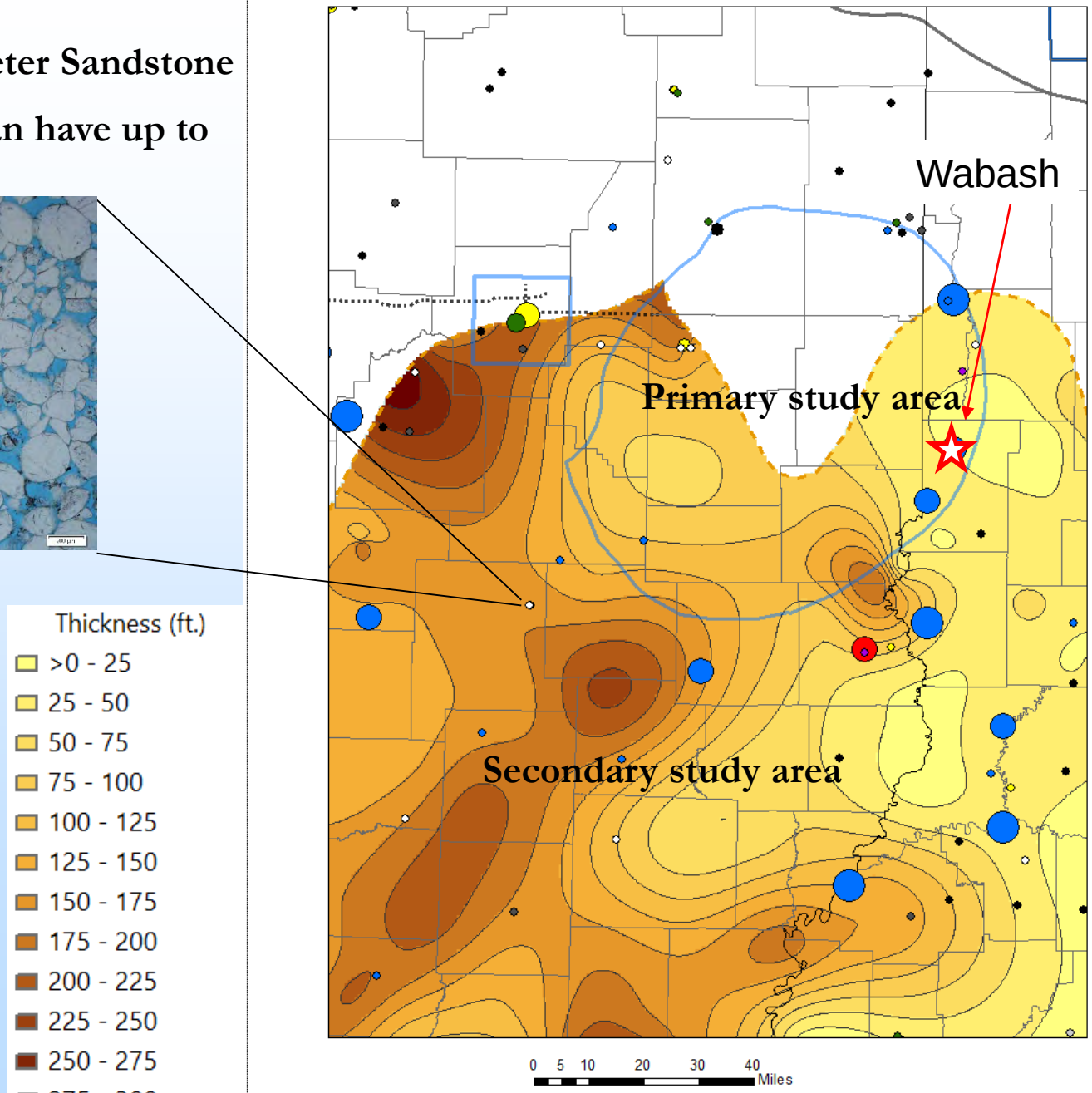




Thickness of the St. Peter Sandstone

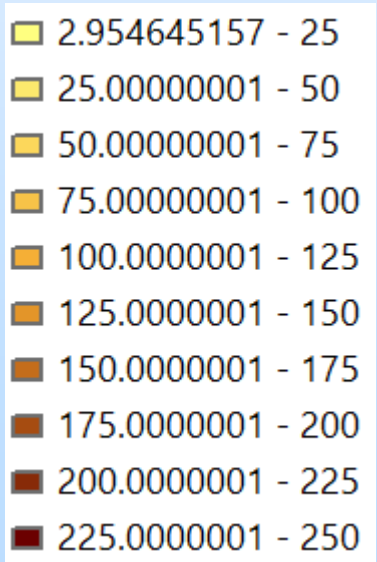
St. Peter Sandstone can have up to 25% porosity

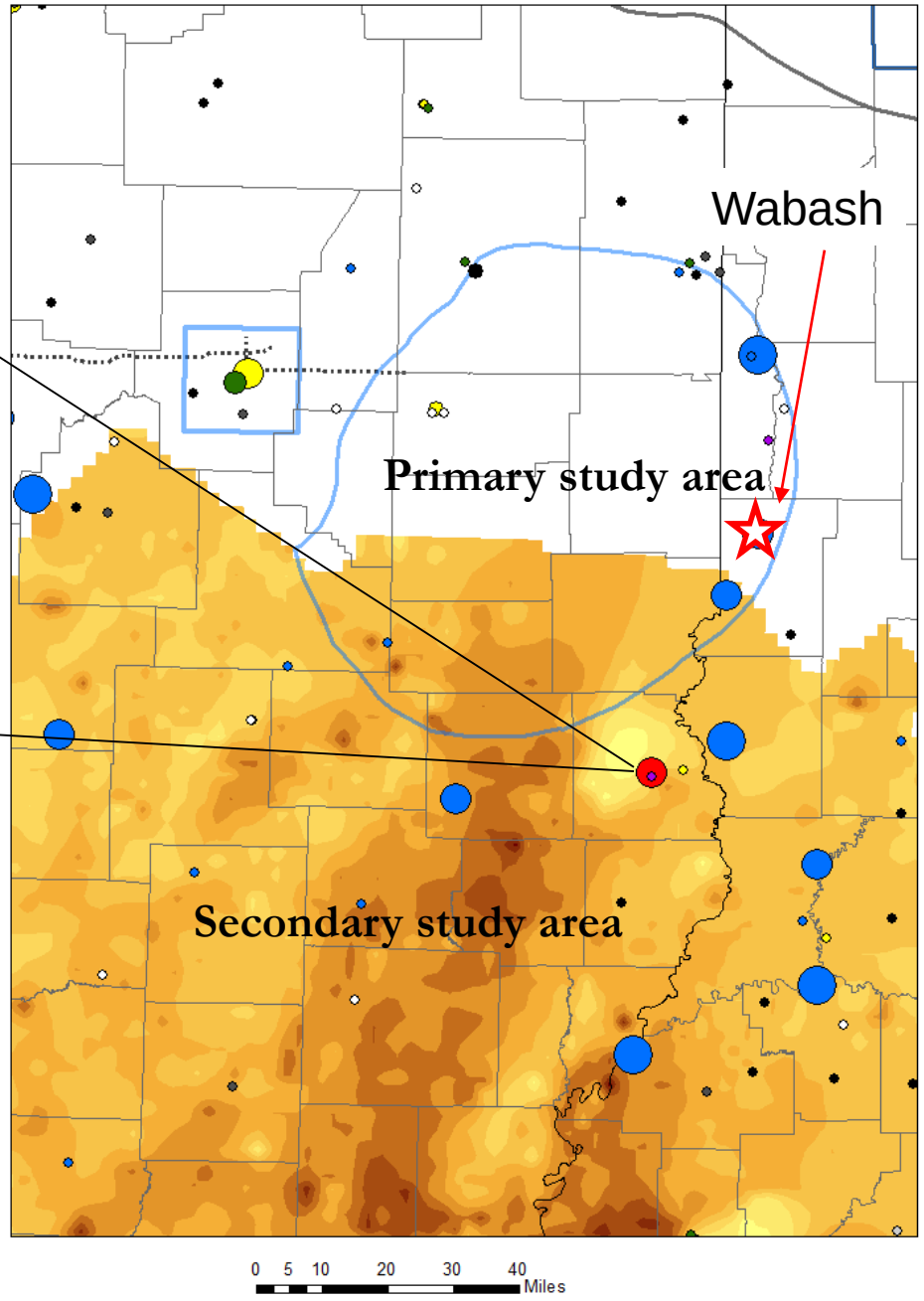




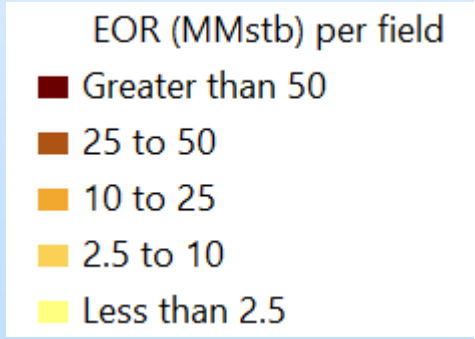
Thickness of the Cypress Sandstone

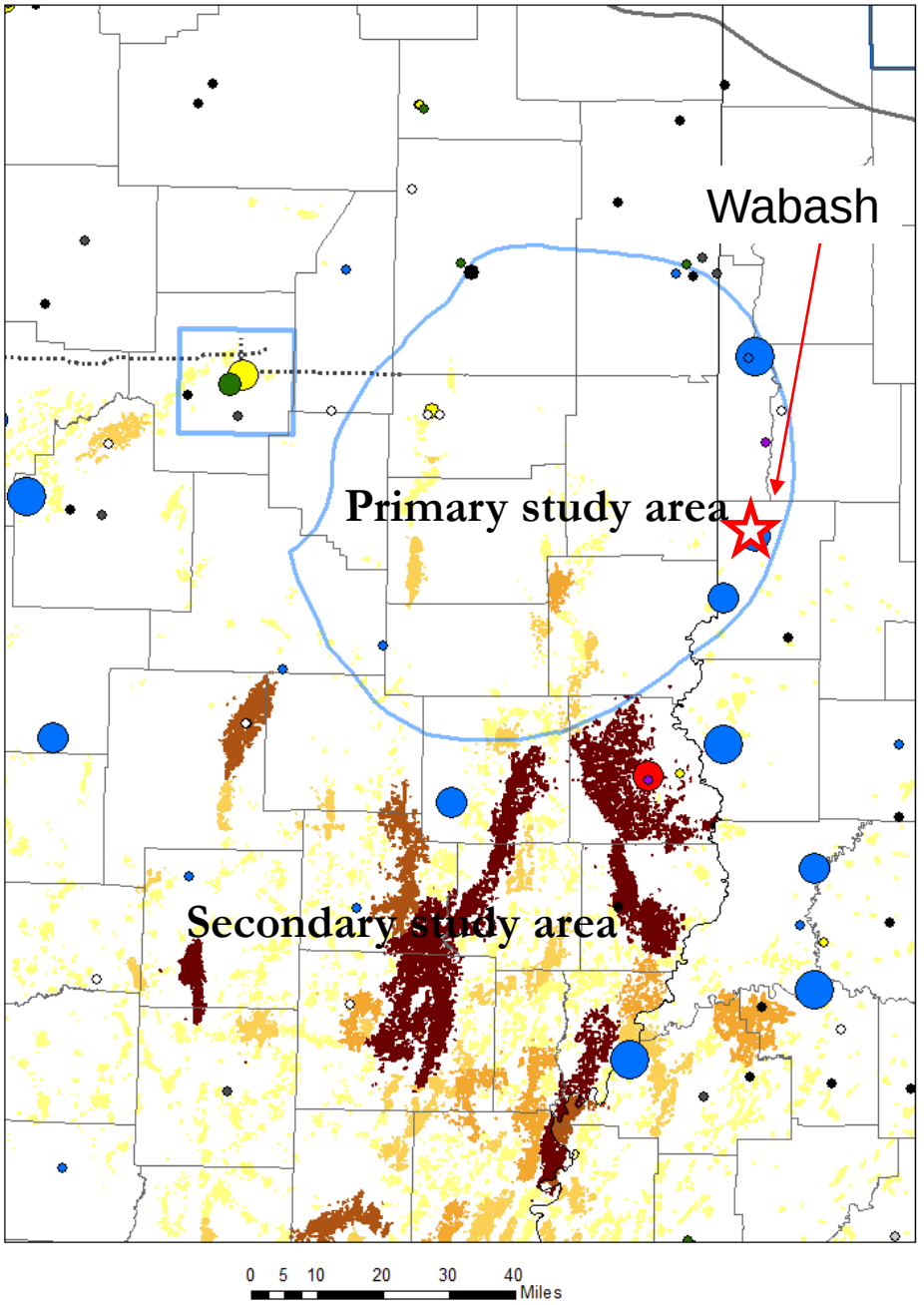
Thick Cypress can have up to 20% porosity





Enhanced Oil Recovery

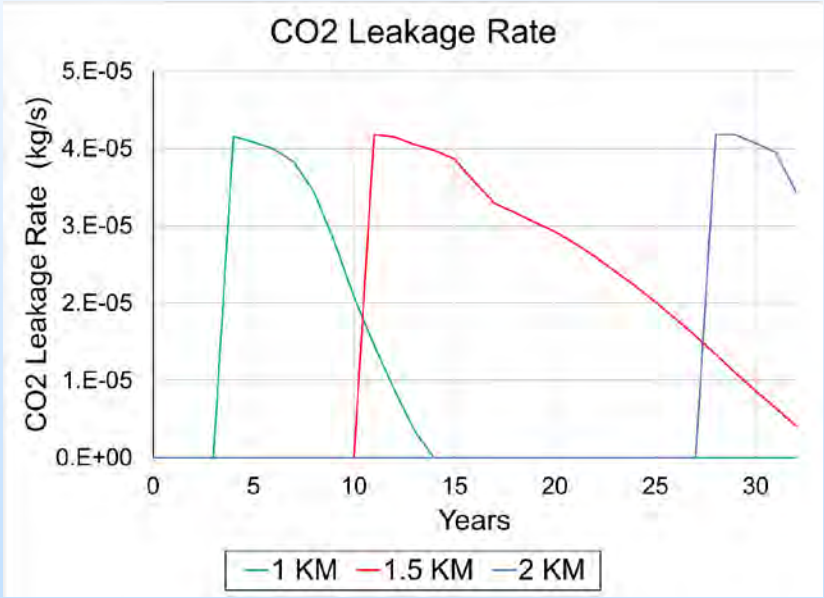




NRAP – IAM Model Results

- Investigated effect of different values of cement permeability on leakage rates
- Results indicate low risk of CO_2 leakage through wells for sites considered
- Identified flaws in tool and provided recommendations for improving future editions of the tool

Rate of CO_2 leakage for three hypothetical wells at 1, 1.5 and 2 km away from injection well



Accomplishments to Date

- This Pre-feasibilty CarbonSAFE Illinois East-subbasin has met most of its deliverables and has resulted in the funding of the Feasiblity Wabash CarbonSAFE project in Indiana.
- Continue work in the primary sub-basin on scaling-in from regional screening toward site feasibility; continue to evaluate the relative merits and/or risks of different focal areas within the secondary study area.
- Completed preliminary discussions with operators of the different sources

Progress on Tasks

Task #	Description	% Complete
1	Project management and planning	**70**
2	Establish CCS Coordination Team	**100**
3	Develop Plan to Address Challenges of Commercial- Scale CCS Project	**30**
4	Conduct High-Level Technical Sub-Basin Evaluation	**80**
5	CO2 Source and Transportation Assessment	**70**
6	National Risk Assessment Partnership (NRAP) Screening	**60**

Lessons Learned

- Greatest challenge is making an economic model from storage into saline reservoirs
- A lack of deep well data near industrial CO_2 sources makes storage and injection analysis difficult

Synergy Opportunities

- There is an opportunity to work on the economic feasibility of CCS with the other participants in the CarbonSAFE program.
- Learn different approaches to evaluating potential sites for large scale CCS projects.
- Many of the industrial sources are along the Illinois-Indiana-Kentucky border motivating further collaboration between state research institutes
  - **This collaboration has resulted in the new CarbonSAFE Feasibility Wabash project**.
- National Risk Assessment Partnership (NRAP) Screening

Project Summary

- This Pre-feasibilty CarbonSAFE Illinois East-subbasin has met most of its deliverables and has resulted in the funding of the Feasiblity Wabash CarbonSAFE project in Indiana
- Continue work in the primary sub-basin on scaling-in from regional screening toward site feasibility; continue to evaluate the relative merits and/or risks of different focal areas within the secondary study area.

Appendix

– These slides will not be discussed during the presentation, but are mandatory.

Benefit to the Program

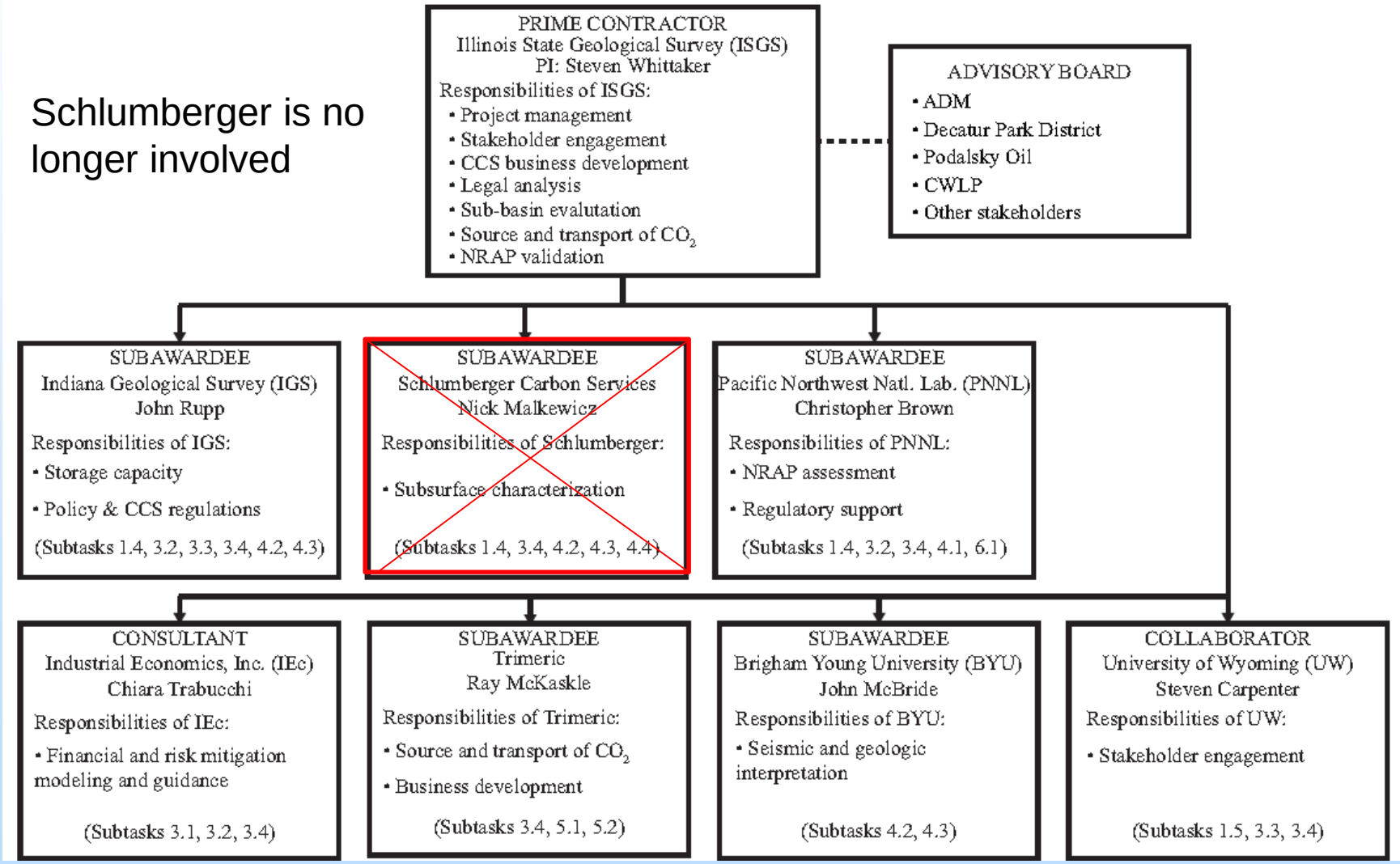
Identifying geological storage sites suitable for storage of over 50 million tonnes of CO_2 is essential for developing commercial-scale CCS projects to address greenhouse gas emissions from industrial sources. There are relatively few large carbon storage projects in deep saline reservoirs, and this gap in development knowledge will be addressed by the research in this project. Our work will address improving our storage capacity estimates to attain an industry standard of ±30% or better for investment decisions. The data from this study will be used within the NRAP Toolkits to move toward validating technologies to ensure storage permanence and to improve reservoir storage efficiency. The knowledge gained will contribute to best practice manuals about CCS technology and issues that will be of broad use to other sites and future commercialization efforts.

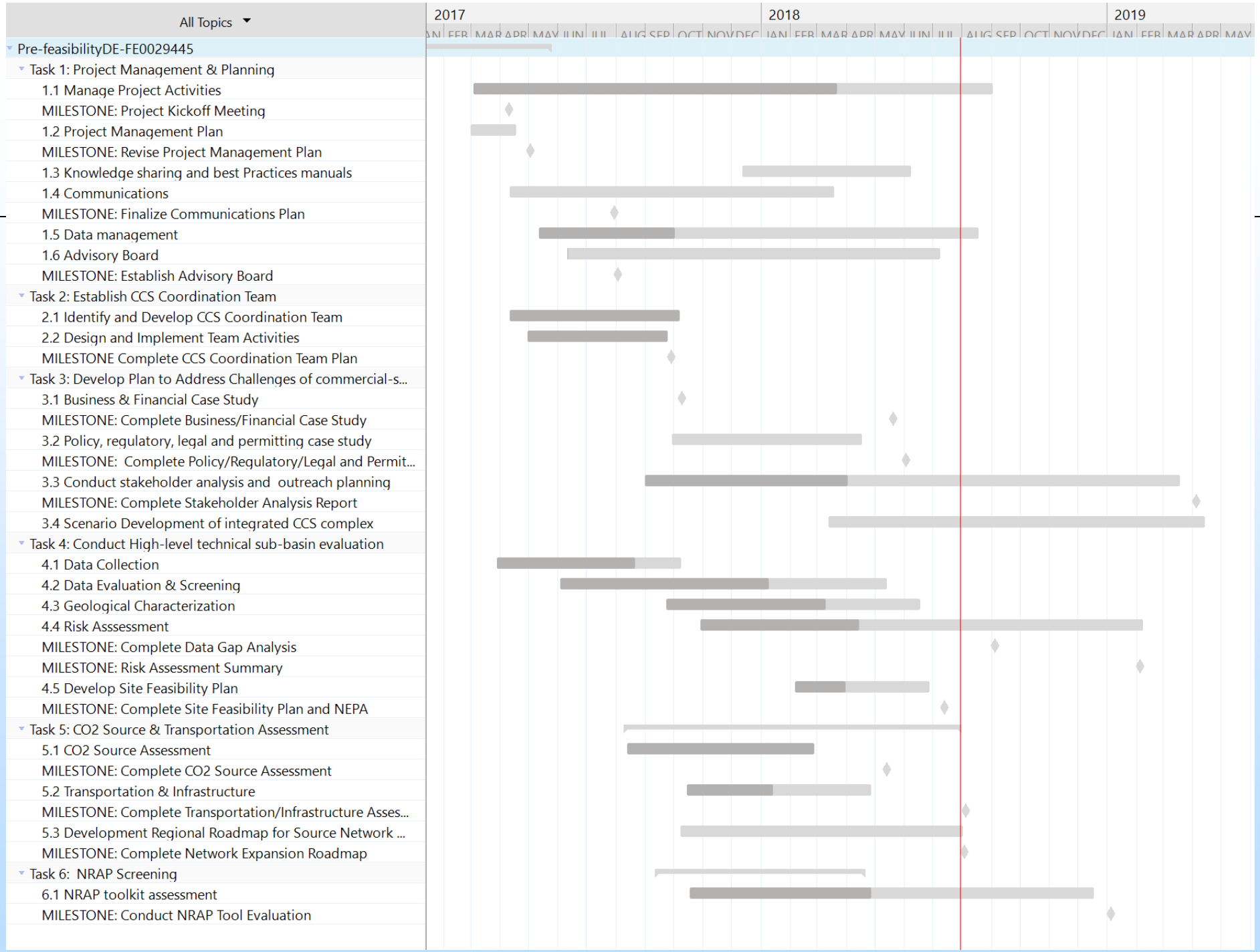
Goals of Project

- Project will conduct a pre-feasibility assessment for commercial-scale geologic carbon storage (CO_2) complexes in the East sub-basin of Illinois.
- Address gaps in experience and knowledge about scaling up from demonstration to commercial-scale storage for more than 50 million tonnes of CO_2 injection from one or more industrial sources

Organization Chart

Schlumberger is no longer involved




All Topics
2017
2018
2019
Pre-feasibilityDE-FE0029445
Task 1: Project Management & Planning
1.1 Manage Project Activities
MILESTONE: Project Kickoff Meeting
1.2 Project Management Plan
MILESTONE: Revise Project Management Plan
1.3 Knowledge sharing and best Practices manuals
1.4 Communications
MILESTONE: Finalize Communications Plan
1.5 Data management
1.6 Advisory Board
MILESTONE: Establish Advisory Board
Task 2: Establish CCS Coordination Team
2.1 Identify and Develop CCS Coordination Team
2.2 Design and Implement Team Activities
MILESTONE Complete CCS Coordination Team Plan
Task 3: Develop Plan to Address Challenges of commercial-s...
3.1 Business & Financial Case Study
MILESTONE: Complete Business/Financial Case Study
3.2 Policy, regulatory, legal and permitting case study
MILESTONE: Complete Policy/Regulatory/Legal and Permit...
3.3 Conduct stakeholder analysis and outreach planning
MILESTONE: Complete Stakeholder Analysis Report
3.4 Scenario Development of integrated CCS complex
Task 4: Conduct High-level technical sub-basin evaluation
4.1 Data Collection
4.2 Data Evaluation & Screening
4.3 Geological Characterization
4.4 Risk Asssessment
MILESTONE: Complete Data Gap Analysis
MILESTONE: Risk Assessment Summary
4.5 Develop Site Feasibility Plan
MILESTONE: Complete Site Feasibility Plan and NEPA
Task 5: CO2 Source & Transportation Assessment
5.1 CO2 Source Assessment
MILESTONE: Complete CO2 Source Assessment
5.2 Transportation & Infrastructure
MILESTONE: Complete Transportation/Infrastructure Asses...
5.3 Development Regional Roadmap for Source Network ...
MILESTONE: Complete Network Expansion Roadmap
Task 6: NRAP Screening
6.1 NRAP toolkit assessment
MILESTONE: Conduct NRAP Tool Evaluation

Bibliography

- Trabucchi, Chiara, 2018, Summary of Carbon Storage Incentives and Potential Legislation: East Sub-Basin Project, Task 3.1 Business and Financial Case Study: DOE Topical Report Number DOE/FE002995-1, May 10,2018, 11 p.
- Patel, V., K. O'Brien, C. Korose, 2018, An Assessment of Potential CO_2 Sources throughout the Illinois Basin Subtask 5.1 CO_2 Source Assessment, DOE Topical Report Number DOE/FE0029445-2, May 9, 2018, 7p.
- Sexton, A. and R. McKaskle, 2018, Subtask 5.2 Transportation and Infrastructure Assessment, DOE Topical Report Number DOE/FE0029445-3, July 31, 2018, 10 p.