Systematic Assessment of Wellbore Integrity for Carbon Storage Projects Using Regulatory and Industry Information

DE-FE0009367

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Battelle Memorial Institute

U.S. Department of Energy
National Energy Technology Laboratory
Carbon Storage R&D Project Review Meeting
Developing the Technologies and Infrastructure for CCS
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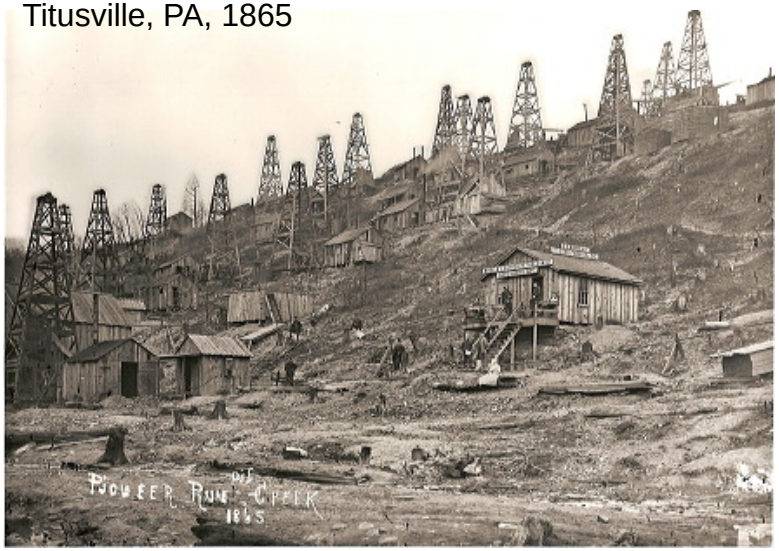
Presentation Outline

- Statement of the Problem
- Benefit to the Program
- Project Overview
- Project Objectives
- Accomplishments to Date
- Summary / Results and Conclusions
- Appendix

Statement of the Problem

- Areas in the Midwest have perceived risk for carbon capture utilization and storage (CCUS) due to long drilling history.
- However, many of the old wells may not present high risk for CCUS because they are shallow or effectively plugged and abandoned.

Titusville, PA, 1865



Source: Drake Well Museum

Morrow County, OH, 1965

13. Cardington, Ohio, U. S. Route 42, looking east-southeast, c. February 1964. A companion to Photograph Number 10.

Source: Ohio Geological Society, 1994

Benefit to the Program

- Existing and plugged and abandoned wellbores are one of the greatest risks for CO_2 migration pathways
- This project will provide a methodology to identify risks and recommend mitigation procedures
  - Area of Interest 1: Studies of Existing Wellbores Exposed to CO_2
  - Develop and validate technologies to ensure 99 percent storage permanence
  - Develop technologies to improve storage efficiency while ensuring containment effectiveness (goals)
- The project will utilize available industry and regulatory data to evaluate well integrity and it will develop effective technology to account for wellbore issues from field evaluation to CO_2 storage field siting

Project Overview

- The project is funded by the U.S. DOE / National Energy Technology Laboratory under their program on technologies to ensure permanent geologic carbon storage (Contract DE-FE0009367).
- Co-funding provided by Ohio Development Services Agency Agreement CDO-D-13-01.
- Project is a three year effort from October 2012-September 2015.
- Project team includes Battelle, BP Alternative Energy, and NiSource
- Project Manager – William O'Dowd, NETL Sequestration Division

U.S. DOE/NETL

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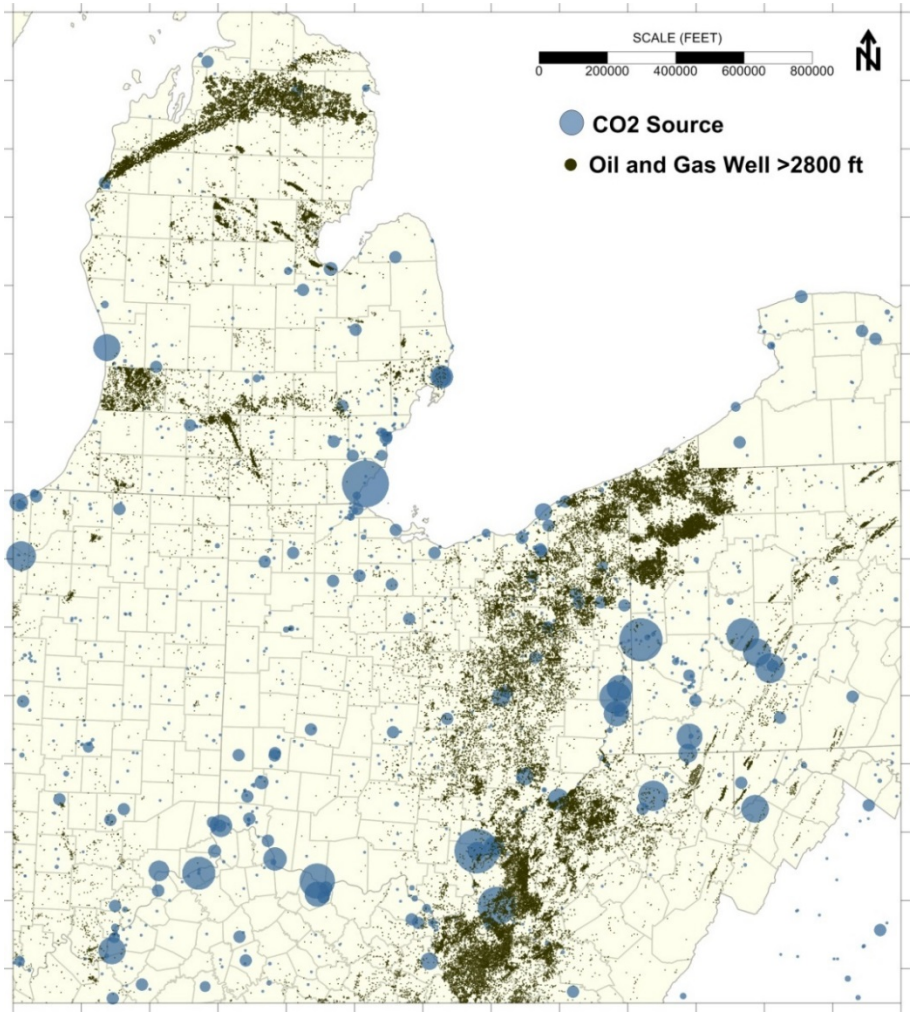
Project Objectives

- The objective of the project is to complete a systematic assessment of wellbore integrity using regulatory and industry information.
- The project will determine the distribution of wellbores in a study area through collection and analysis of well records.
- The data review will be linked to analysis of well casing annulus pressure data as they relate to well condition.
- Project results will identify and develop methodologies that can indicate future wellbore integrity risks from available public domain data with high confidence.

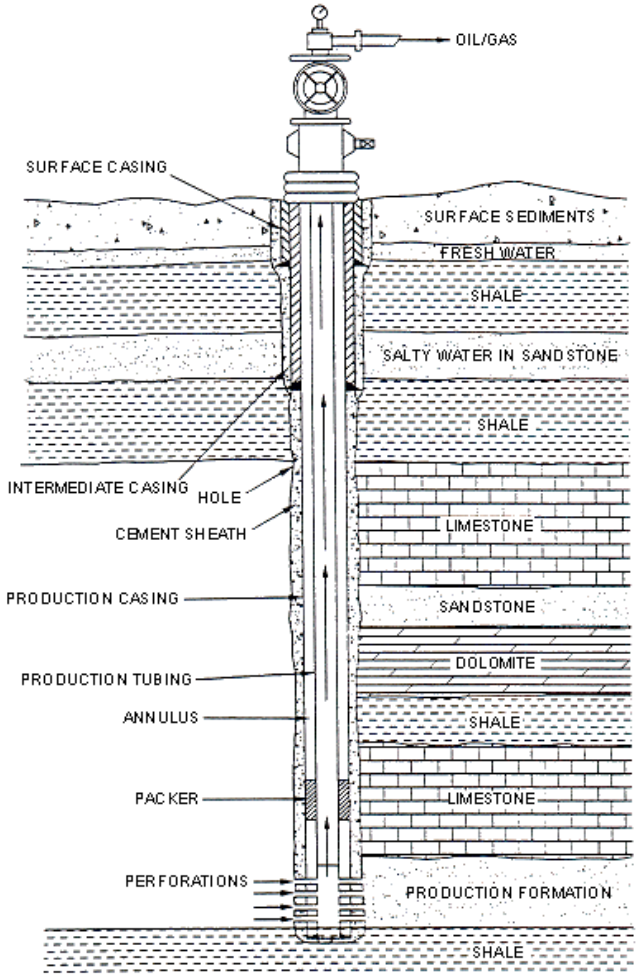
Project Objectives

- The project will summarize remediation and plugging methods, costs, and level of effort for potential CO_2 storage zones.
- Based on the well integrity evaluation, guidance will be developed for siting CO_2 storage applications.
- Key storage targets will be identified with least risk from abandoned wells.
- Technology guidance will be provided for well completion and abandonment applications.

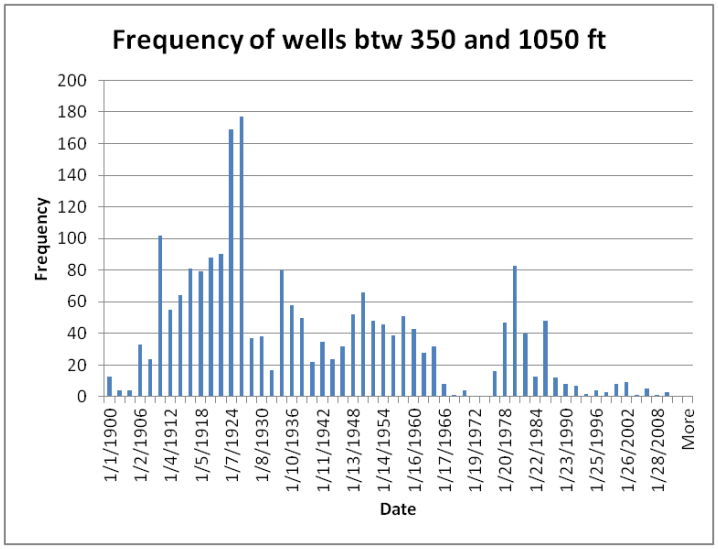


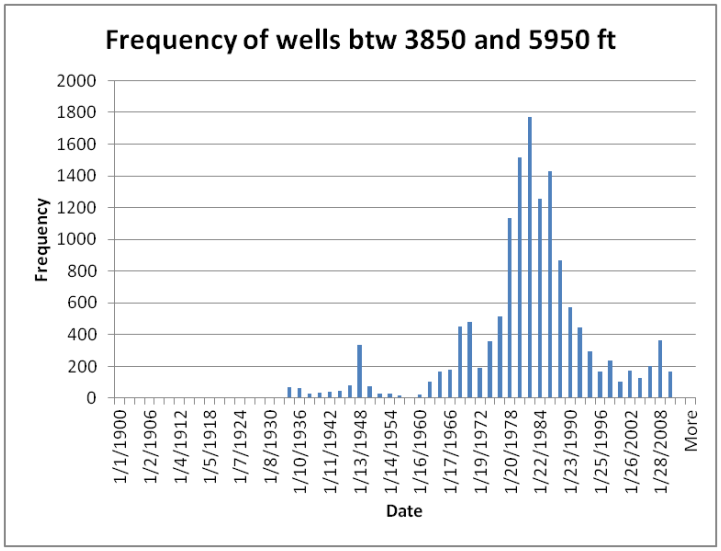
Accomplishments to Date

- Completed Well Record Gathering and Compilation
  - 248,000 wells in Ohio and Michigan
    - 49% of the wells drilled in Ohio have been plugged
    - 65% of the wells drilled in Michigan have been plugged

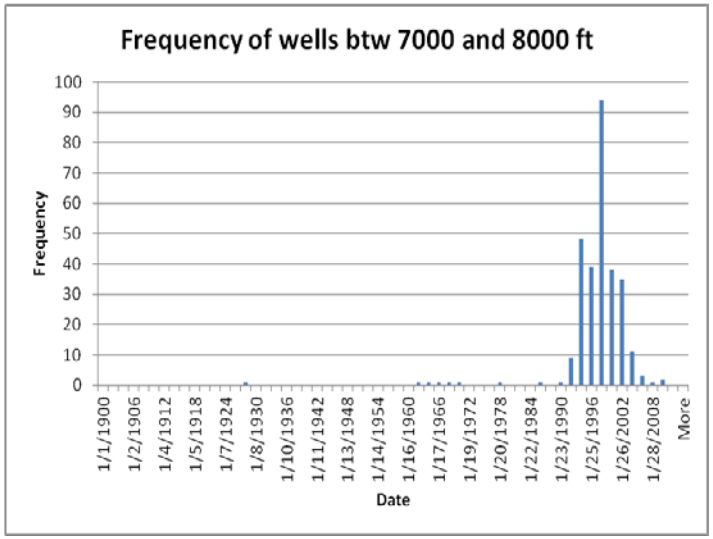


Well History Review- NE Ohio





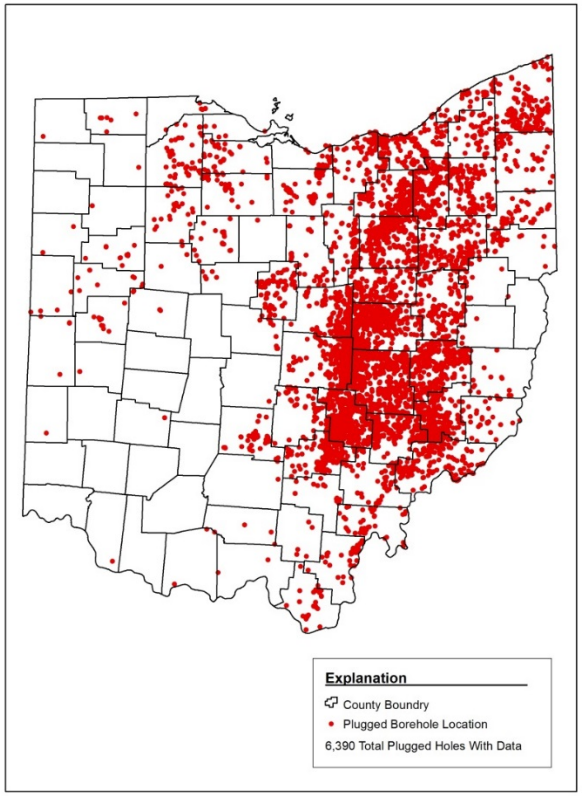
Majority of vintage wells were drilled to shallow producing formations which pose little risk of CO_2 leakage from deep storage wells.

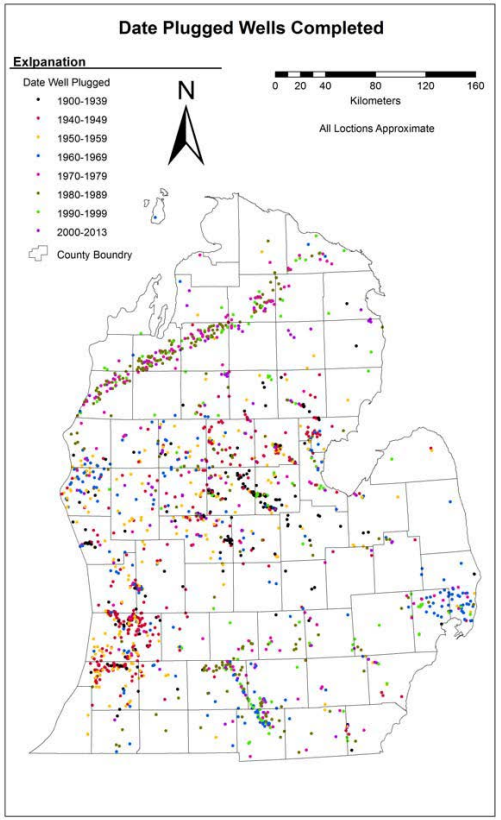


Majority of deep wells were recently drilled and constructed under modern regulations which reduces there risk of leakage pathways.

Accomplishments to Date

- Analyzed 1,730 plugged and abandoned wells in Ohio and Michigan
- Evaluated for number of plugs, depth of plugs, thickness of plugs, plugging materials and additives





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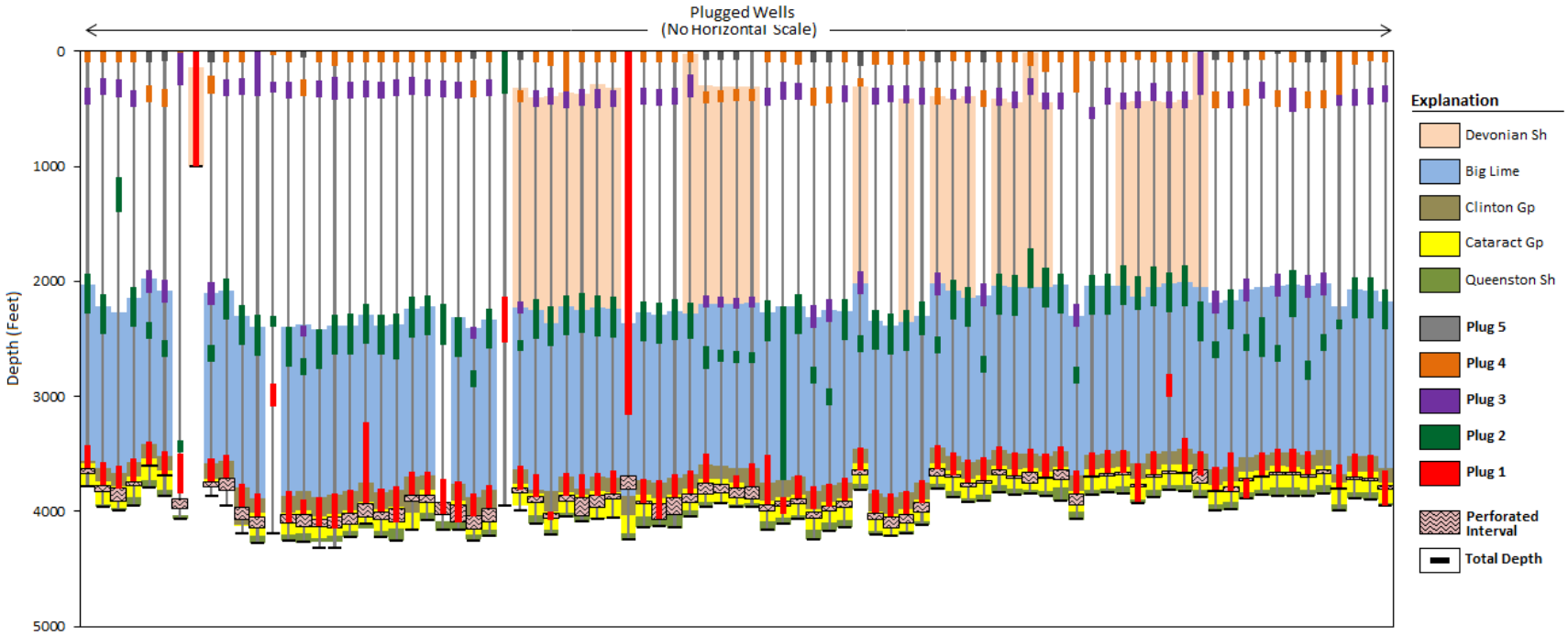
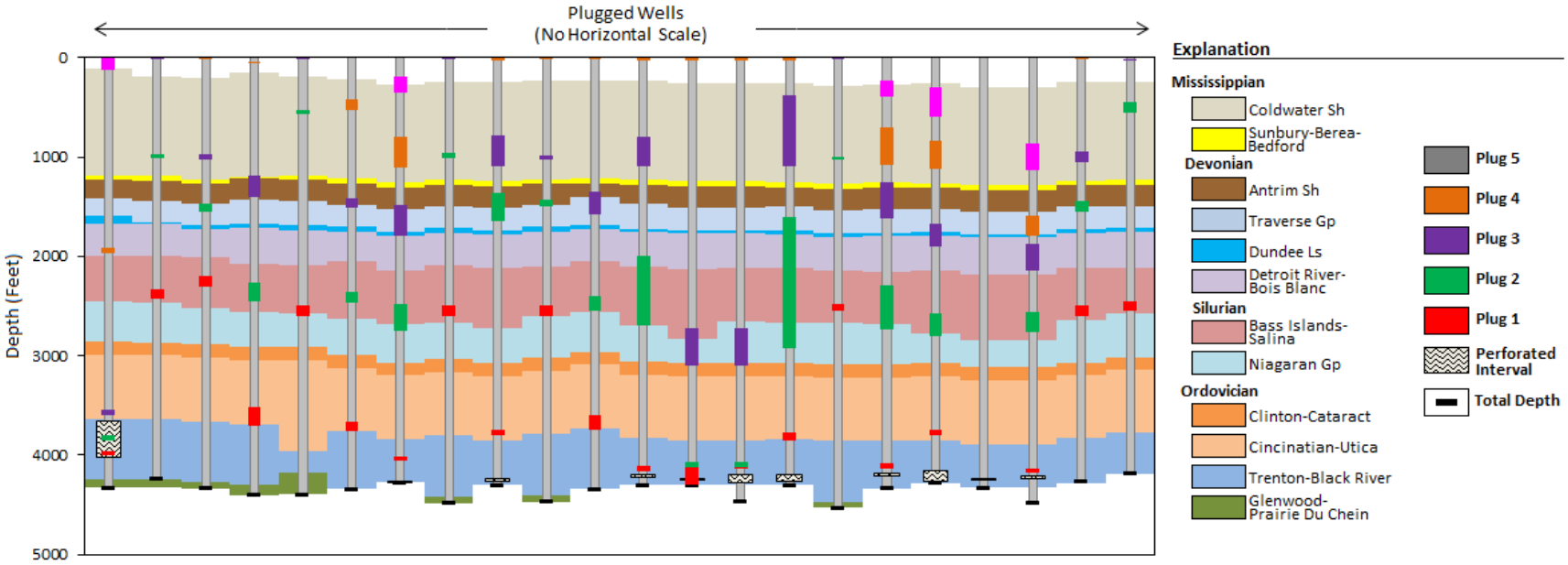
Ohio test area: chart showing casing depth and plugged intervals



Side by side comparison of 86 wells

Michigan test area: chart showing casing depth and plugged intervals



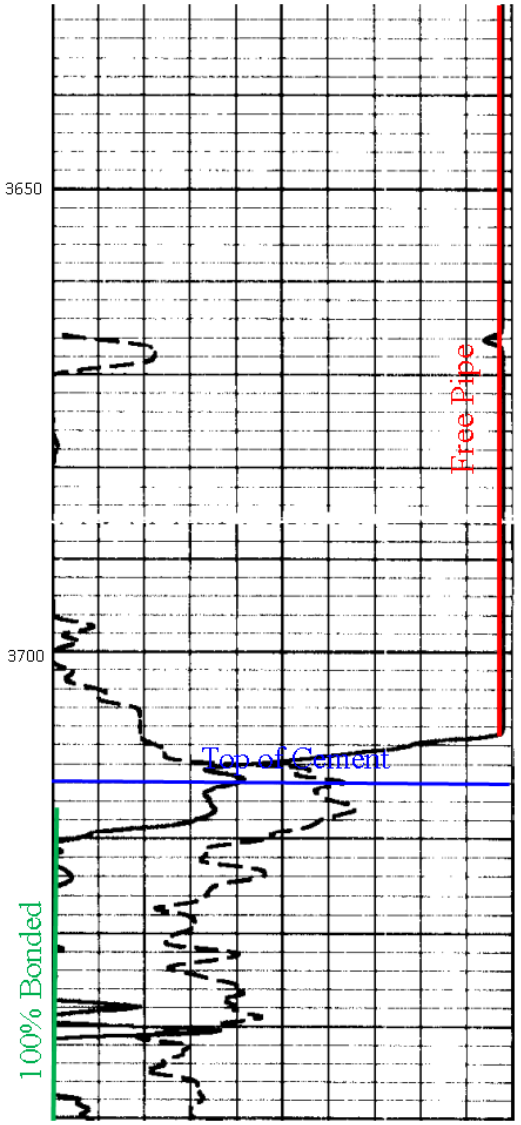
Side by side comparison of 22 wells

Accomplishments to Date

- Gathered cement bond logs (CBL) for 278 wells in Ohio and Michigan
  - Developed a tool for systematic, consistent evaluation of CBLs
- Gathered field data from 13 wells exhibiting Sustained Casing Pressure (SCP)
  - Production casings on 9 of the 13 wells were cemented back to ground level.
  - Developed systematic field procedures for acquiring gas samples and pressure data for SCP evaluation
  - Developing a “cement defect factor” to rank faulty cement jobs

Cement Bond Log (CBL) Evaluation

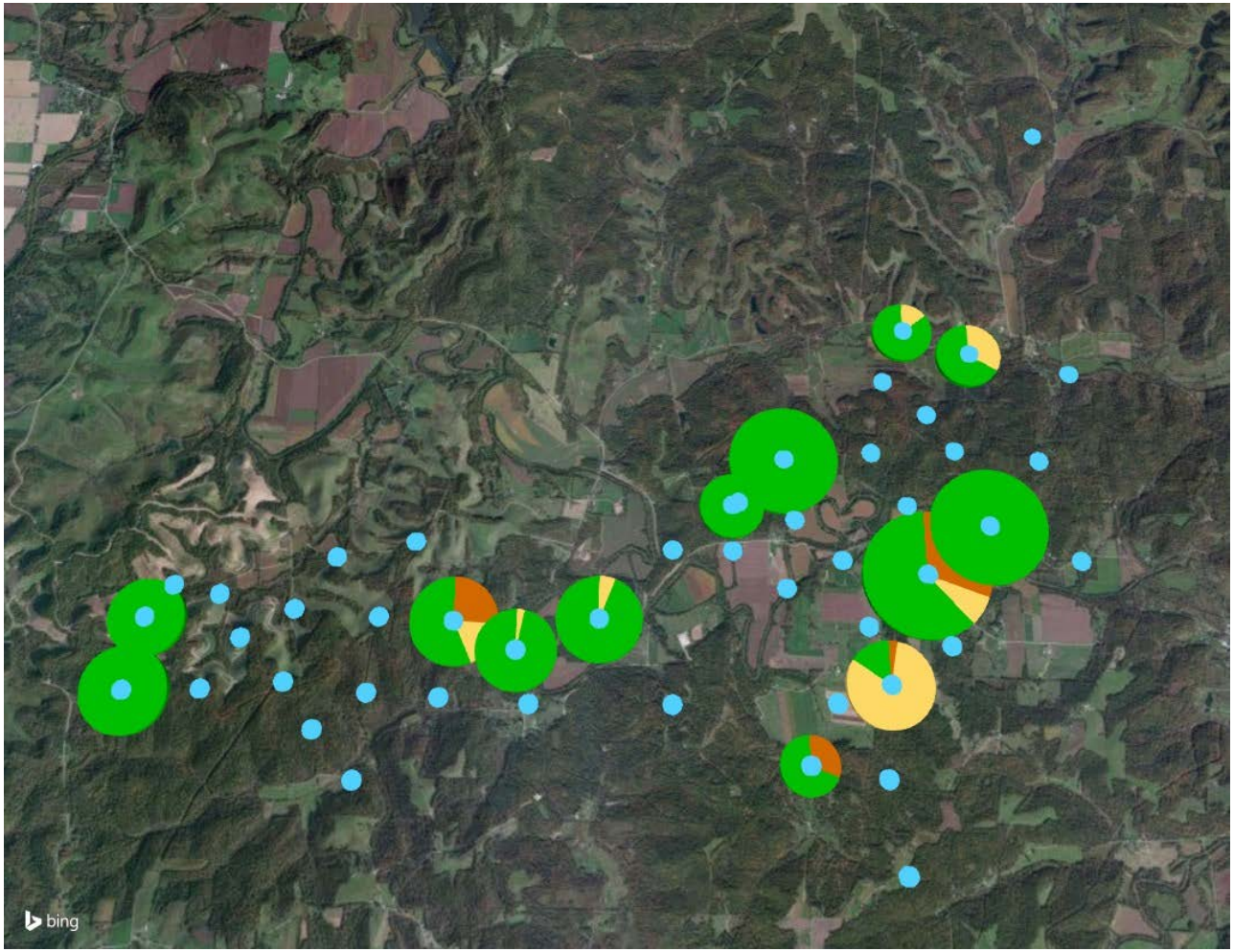
- Basic tool works by sending a sonic signal into the wellbore and recording the loss of signal
- Response can be considered highly subjective and interpretations are often cumbersome and difficult to repeat
- Interpretation of CBLs is very qualitative and therefore interpreted results can vary widely
- A systematic CBL evaluation method was developed to make interpretations more consistent
- Results of analysis show high repeatability in the methodology



CBL Evaluation

Cement quality
in intervals

- 80-100%
- 60-80%
- <60%

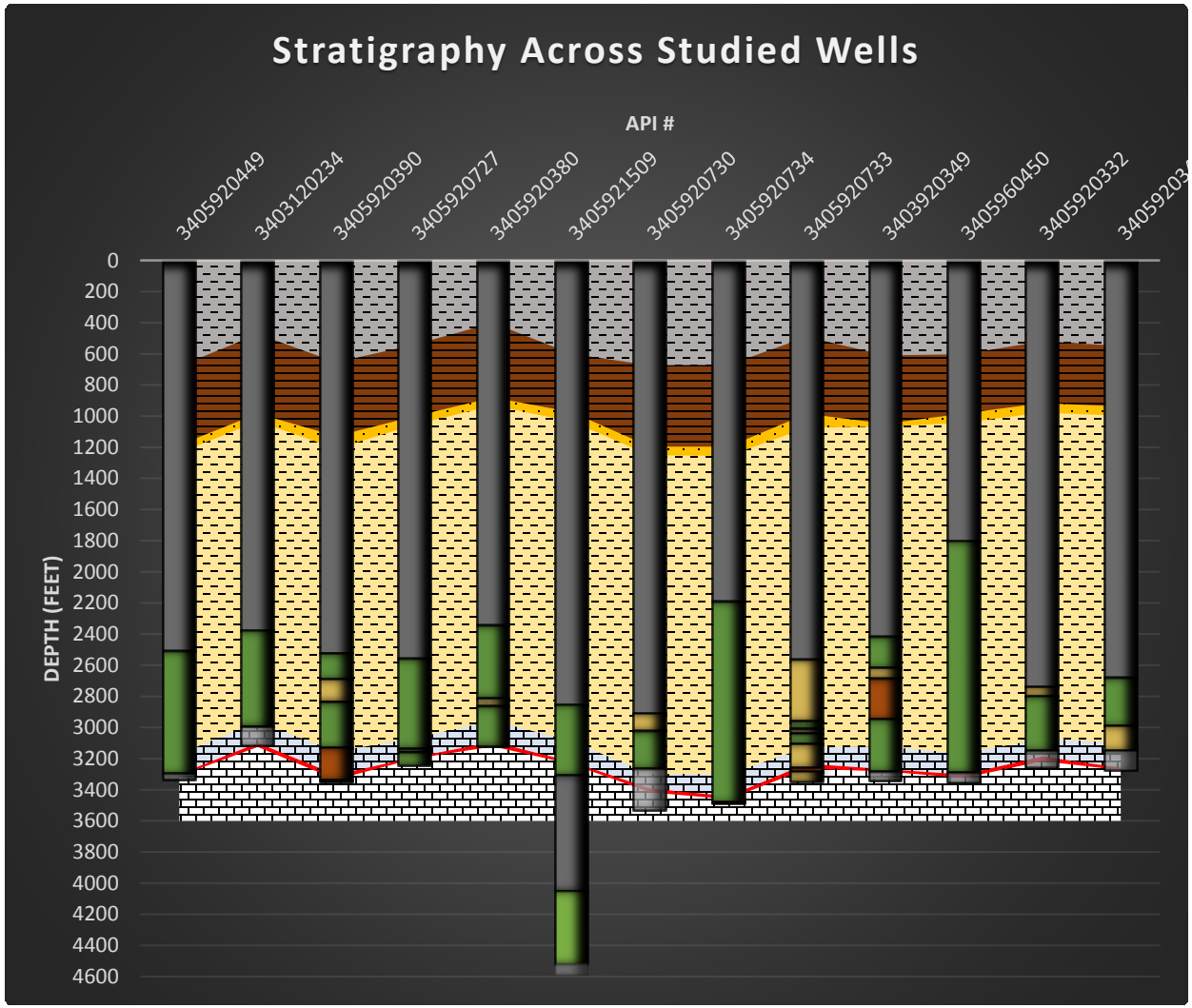


CBL Evaluation

Stratigraphy

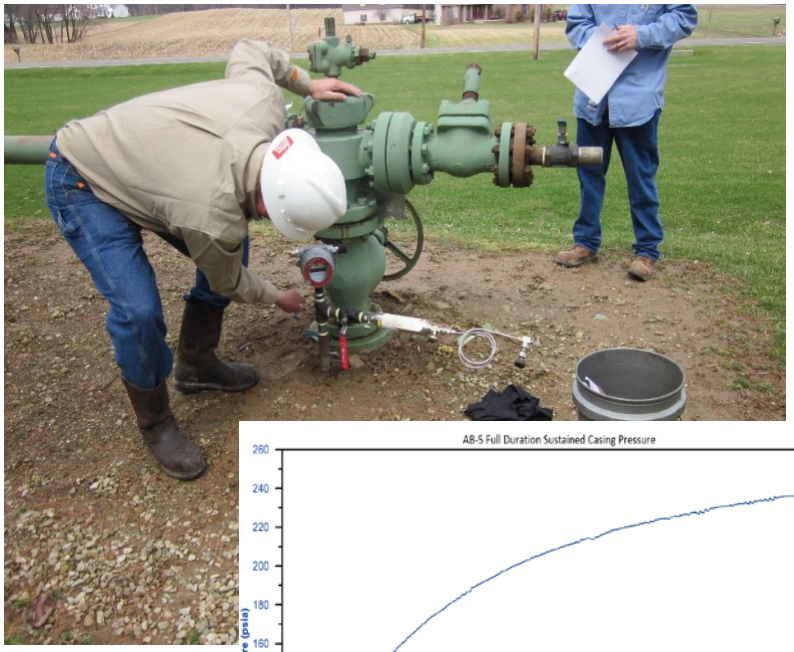
- Undifferentiated Penn-Miss
- Sunbury
- Berea
- Devonian Shale
- Onondaga
- Oriskany
- Limestone

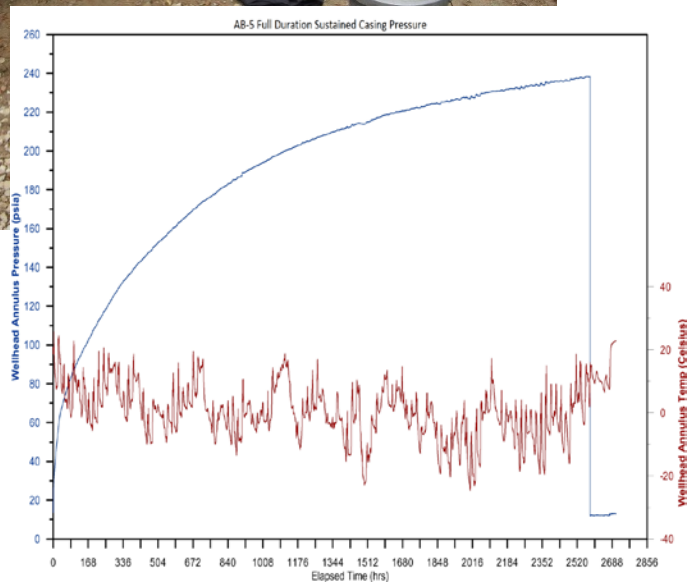
Bond
- 80-100%
- 60-80%
- <60%



Sustained Casing Pressure (SCP)

- Based on the observations of 13 wells, SCP can occur and be influenced by factors other than defective cement across the completed zone.
- SCP is not always a reliable indicator of the quality of the cement seal at depth.
- However, the process used to collect and analyze SCP data can be a reliable tool for determining zonal isolation in legacy wells.





Sustained Casing Pressure (SCP)

- SCP can come from a leak in the casing and/or tubing, defects in the cement, or from sources above the cement
- The chemical composition of the gas and the maximum surface pressure can often be used to determine the probable source of the gas

SCP Analysis Metrics

- **Instant Release Metric (IRM)**
  - Indicate potential volume of sudden gas release
  - Unit is MSCF

$$IRM \sim f(P_{asym}, V_g)$$

- **Sustained Leakage Metric (SLM)**
  - Maximum possible gas leakage rate
  - Unit is MSCFD

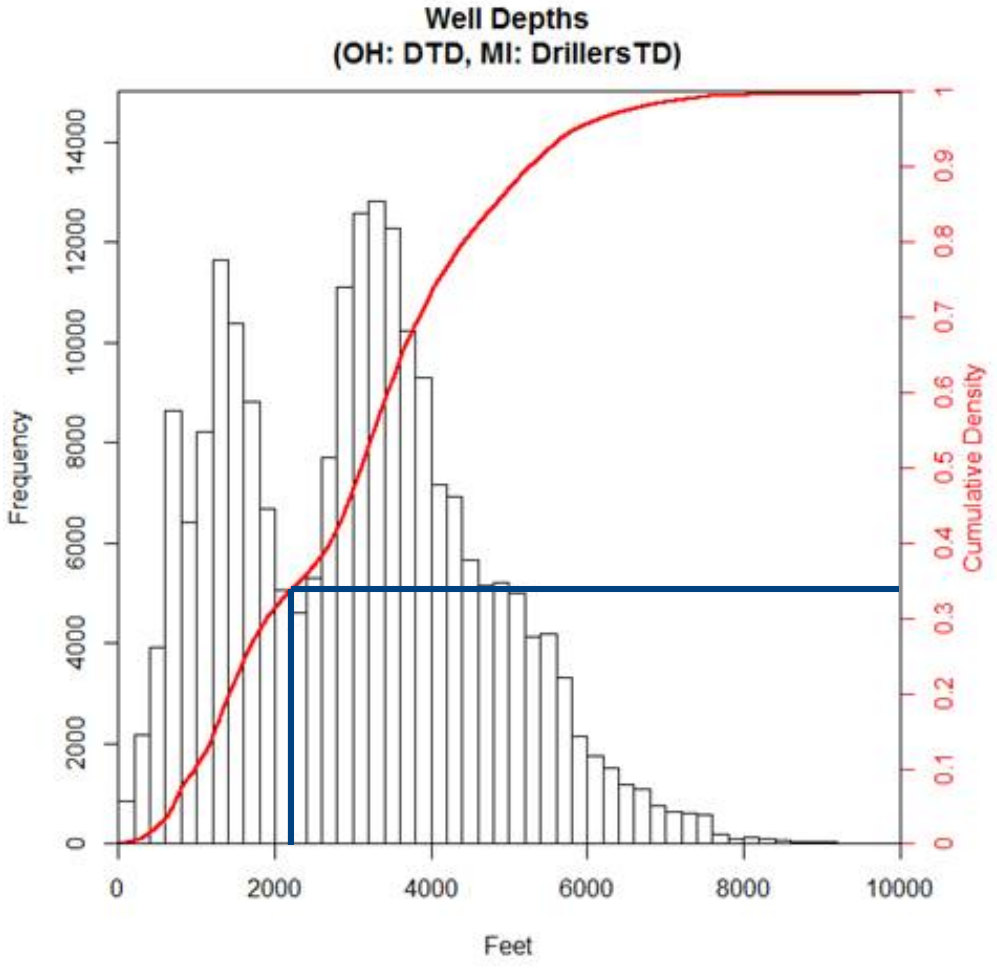
$$SLM \sim DF$$

- **Defect Factor (DF)**
  - Predict well integrity for containment
  - Unit is μm^2

Statistical Analysis

Total Number of Wells versus Depth with Cumulative Density

Approximately 35% of the wells in the database are 2,200 ft. or less in depth and probably pose very little risk for CO_2 migration pathways



Summary

- Gathered and compiled data from 248,000 wells in Ohio and Michigan
  - Depth, age, construction (casing and cementing program), completion, well status
- Gathered and compiled data from 1,730 plugged and abandoned wells in Ohio and Michigan
- Evaluated 278 Cement Bond Logs in Ohio and Michigan
  - CBL evaluations indicate that most wells have the minimum bond required for zonal isolation
- Gathered and evaluated Sustained Casing Pressure (SCP) data from 13 wells
- Applying statistical analyses to all data to look for trends and/or anomalies

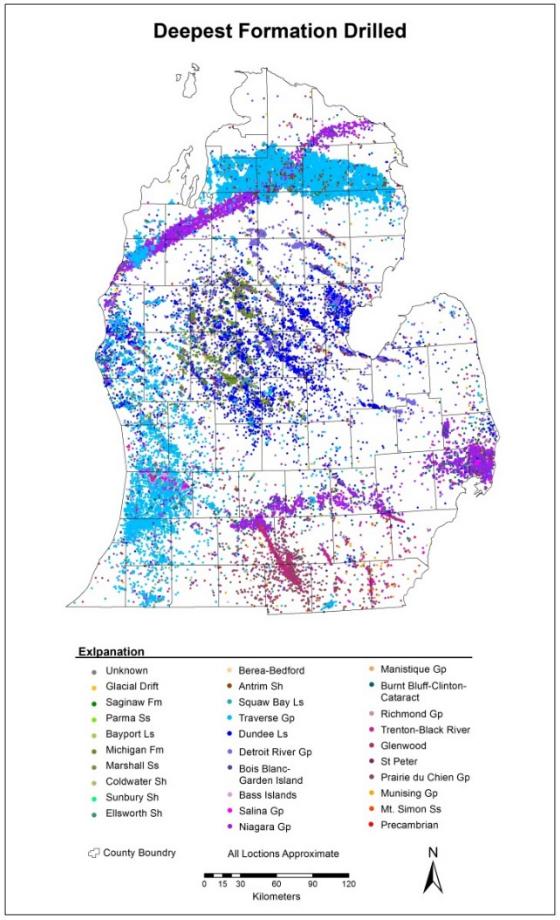
Lessons Learned

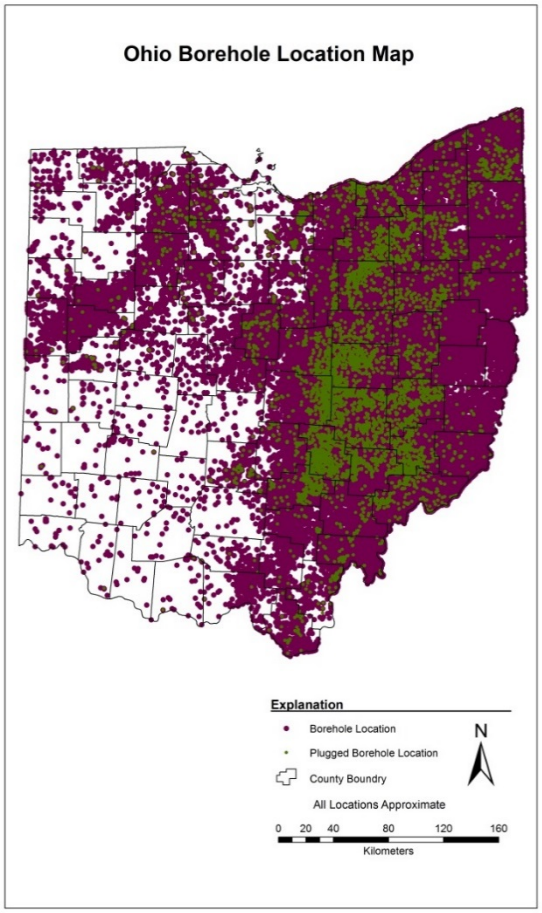
- SCP is not a reliable indicator of the quality of the cement seal at depth for these tested wells.
  - The source of SCP is often from gas producing zones up hole
- However, the process used to collect SCP data can be a reliable tool for determining zonal isolation in legacy wells.
- Public records require QA/QC to be considered useful data.

Future Plans

- Linking data to test area analysis
- Finalizing CBL evaluation tool
- Development of quick-look mapping procedures to determine high risk wells or areas
- Developing a corrective action summary for addressing high risk wells
- Compiling data on deep wells in Ohio and Michigan

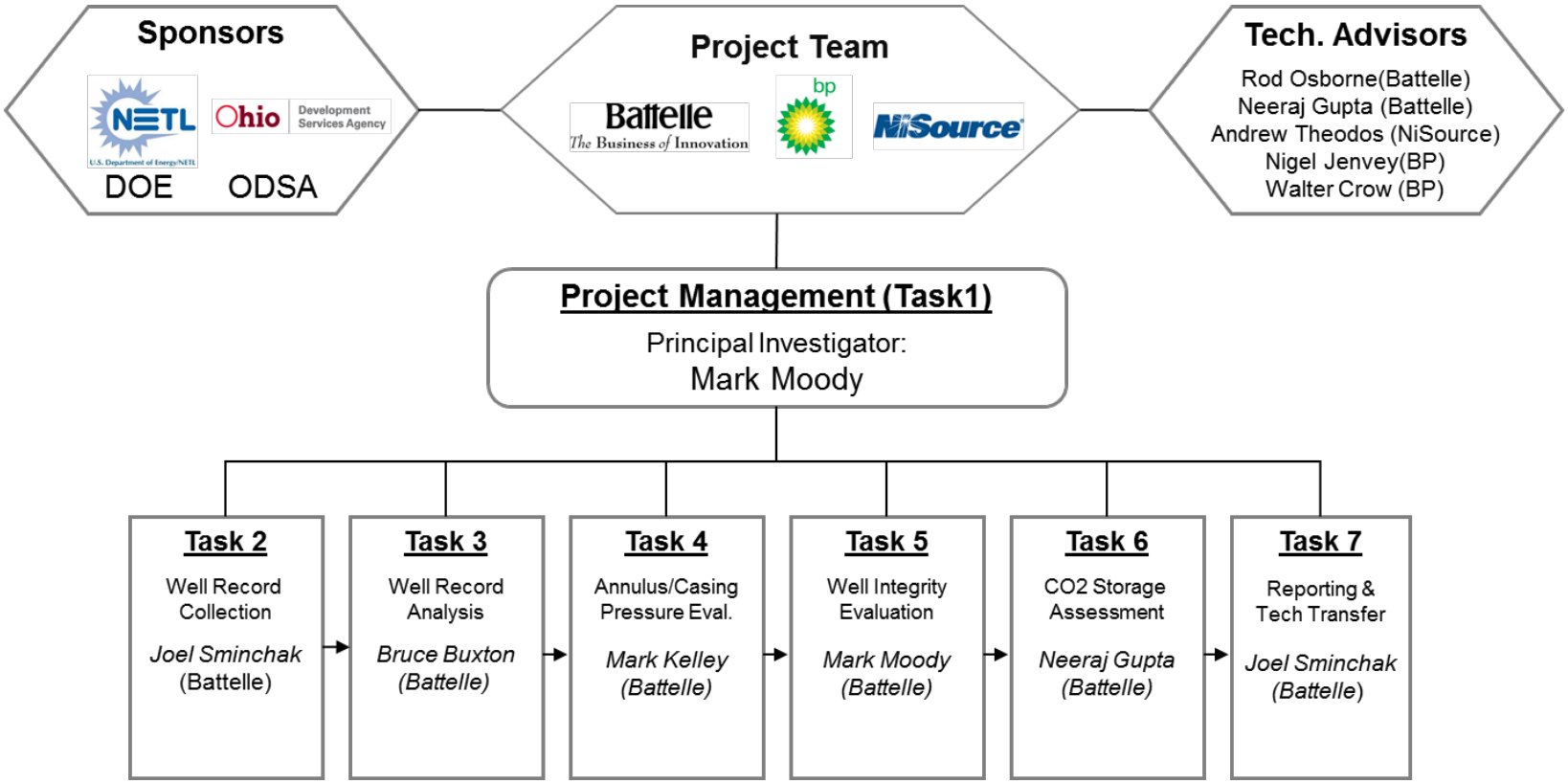
Questions ???





Appendix

Organizational Chart



Project Schedule

Task Name	BP1				BP2				BP3			
	FY2013				FY2014				2015			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1: Project Management												
1.1 Project Management & Planning												
1.2 Update Project Mgmt. Plan	X											
1.3 Progress Reporting	X	X	X	X	□	□	□	□	□	□	□	□
1.4 Project Controls												
1.5 Deliverables and Reporting			X			□	□	□		□	□	
Task 2: Well Record Collection												
2.1 Regional Well History Review												
2.2 Review of Historical Practices in Region												
2.3 OH-PA Study Area Well Rec. Collection												
2.4 S-C MI Study Area Well Rec. Collection												
2.5 Casing/Annulus Pressure Data Collection												
2.6 Data Compilation and Review												
Task 3: Well Record Analysis												
3.1 Regional Well History Analysis												
3.2 OH-PA Study Area Data Analysis												
3.3 S-C MI Study Area Data Analysis												
3.4 Casinsing/Annulus Pressure Analysis												
3.5 Statistical Record Analysis												
Task 4: Casing/Annulus Pressure Eval.												
4.1 Casing/Annulus Pres. Field Data Collect.												
4.2 Pressure Temperature Data Analysis												
Task 5: Well Integrity Evaluation												
5.1 Cement Evaluation												
5.2 Casing Condition Evaluation												
5.3 Hydrogeologic Condition Evaluation												
Task 6: CO_2 Storage Assessment												
6.1 Well Integrity Risk Factors												
6.2 Remedial Guidance												
6.2 CO_2 Storage Siting Guidance												
Task 7: Reporting and Tech Transfer												
7.1 Progress Reporting												
7.2 Technical Reports			X			□	□	□		□	□	
7.3 Final Reporting												
7.4 Project Meetings												

u = project milestone X = completed project milestone
= indicates task that has been extended due to field work delays or additional analysis.