DOE F 4600.2
(03/11)
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**U.S. Department of Energy**
**FEDERAL ASSISTANCE REPORTING CHECKLIST**
**AND INSTRUCTIONS FOR RD&D PROJECTS**

| 1. Identification Number: **DE-FE0006821** | 2. Program/Project Title: **Small Scale Field Test Demonstration CO2 Sequestration** |
|---|---|
| 3. Recipient: **University of Kansas Center for Research, Inc.** | |

| 4. Reporting Requirements: | Frequency | Addressees |
|---|---|---|
| **A. MANAGEMENT REPORTING** | | |
| ☒ Research Performance Progress Report (RPPR) | Q | FITS@NETL.DOE.GOV |
| ☒ Special Status Report | A | FITS@NETL.DOE.GOV |
| **B. SCIENTIFIC/TECHNICAL REPORTING** | | |
| (Reports/Products must be submitted with appropriate DOE F 241. The 241 forms are available at www.osti.gov/elink) | | |
| Report/Product — Form | | |
| ☒ Final Scientific/Technical Report — DOE F 241.3 | FG | http://www.osti.gov/elink-2413 |
| ☒ Conference papers/proceedings* — DOE F 241.3 | A | http://www.osti.gov/elink-2413 |
| ☐ Software/Manual — DOE F 241.4 | | |
| ☐ Other (see special instructions) — DOE F 241.3 | | |
| ** Scientific and technical conferences only* | | |
| **C. FINANCIAL REPORTING** | | |
| ☒ SF-425 Federal Financial Report | Q, FG | FITS@NETL.DOE.GOV |
| **D. CLOSEOUT REPORTING** | | |
| ☒ Patent Certification | FC | FITS@NETL.DOE.GOV |
| ☒ SF-428 & 428B Final Property Report | FC | FITS@NETL.DOE.GOV |
| ☐ Other | | |
| **E. OTHER REPORTING** | | |
| ☒ Annual Indirect Cost Proposal | O | See block 5 below for instructions. |
| ☐ Audit of For-Profit Recipients | | |
| ☒ SF-428 Tangible Personal Property Report Forms Family | A | FITS@NETL.DOE.GOV |
| ☒ Other – see block 5 below | A | FITS@NETL.DOE.GOV |

FREQUENCY CODES AND DUE DATES:

A - Within 5 calendar days after events or as specified.
FG- Final; 90 calendar days after the project period ends.
FC- Final; End of Effort.
Y - Yearly; 90 calendar days after the end of the reporting period.
S - Semiannually; within 30 calendar days after end of project year and project half-year.
Q - Quarterly; within 30 days after end of the reporting period.
Y180 – Yearly; 180 days after the end of the recipient's fiscal year
O - Other; See instructions for further details.

5. Special Instructions:

**Annual Indirect Cost Proposal** – If DOE is the Cognizant Federal Agency, then the proposal should be sent to FITS@NETL.DOE.GOV . Otherwise, it should be sent to the Cognizant Federal Agency.

Other – The Recipient shall provide all deliverables as contained in Section D of Attachment 2 Statement of Project Objectives.

**QUARTERLY PROGRESS REPORT**
**To**
**DOE-NETL**
**Brian Dressel, Program Manager**
**Award Number: DE-FE0006821**

# SMALL SCALE FIELD TEST DEMONSTRATING $CO_2$ SEQUESTRATION IN ARBUCKLE SALINE AQUIFER AND BY $CO_2$-EOR AT WELLINGTON FIELD, SUMNER COUNTY, KANSAS

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**Joint Principal Investigator:**
**Jason Rush**

**Prepared by Lynn Watney**
**Date of Report: November 5, 2013**
**DUNS Number:** 076248616

**Recipient: University of Kansas Center for Research &**
**Kansas Geological Survey**
**1930 Constant Avenue**
**Lawrence, KS 66047**

**Project/Grant Period: 10/1/2011 through 9/30/2015**

**Eighth Quarterly Report**

**Period Covered by the Report: July 1, 2013 through September 30, 2013**

**Signature of Submitting Official:**

W. Lynn Watney

# EXECUTIVE SUMMARY

## Project Objectives

The objectives of this project are to understand the processes that occur when a maximum of 70,000 metric tonnes of $CO_2$ are injected into two different formations to evaluate the response in different lithofacies and depositional environments. The evaluation will be accomplished through the use of both *in situ* and indirect MVA (monitoring, verification, and accounting) technologies. The project will optimize for carbon storage accounting for 99% of the $CO_2$ using lab and field testing and comprehensive characterization and modeling techniques.

$CO_2$ will be injected under supercritical conditions to demonstrate state-of-the-art MVA tools and techniques to monitor and visualize the injected $CO_2$ plume and to refine geomodels developed using nearly continuous core, exhaustive wireline logs, and well tests and a multi-component 3D seismic survey. Reservoir simulation studies will map the injected $CO_2$ plume and estimate tonnage of $CO_2$ stored in solution, as residual gas, and by mineralization and integrate MVA results and reservoir models shall be used to evaluate $CO_2$ leakage. A rapid-response mitigation plan will be developed to minimize $CO_2$ leakage and provide comprehensive risk management strategy. A documentation of best practice methodologies for MVA and application for closure of the carbon storage test will complete the project. The $CO_2$ shall be supplied from a reliable facility and have an adequate delivery and quality of $CO_2$. The project shall install compression, chilling, and transport facilities at the ethanol plant for truck transport to the injection site.

## Scope of Work

Budget Period 1 includes updating reservoirs models at Wellington Field and filing Class II and Class VI injection permit applications. Static 3D geocellular models of the Mississippian and Arbuckle shall integrate petrophysical information from core, wireline logs, and well tests with spatial and attribute information from their respective 3D seismic volumes. Dynamic models (composition simulations) of these reservoirs shall incorporate this information with laboratory data obtained from rock and fluid analyses to predict the properties of the CO2 plume through time. The results will be used as the basis to establish the MVA and as a basis to compare with actual CO2 injection. The small scale field test shall evaluate the accuracy of the models as a means to refine them in order to improve the predictions of the behavior and fate of CO2 and optimizing carbon storage.

Budget Period 2 includes drilling and equipping a new borehole into the Mississippian reservoir for use in the first phase of CO2 injection; establishing MVA infrastructure and acquiring baseline data; establishing source of CO2 and transportation to the injection site; building injection facilities in the oil field; and injecting CO2 into the Mississippian-age spiculitic cherty dolomitic open marine carbonate reservoir as part of the small scale carbon storage project.

In Budget Period 3, contingent on securing a Class VI injection permit, the drilling and completion of an observation well will be done to monitor injection of CO2 under supercritical conditions into the Lower Ordovician Arbuckle shallow (peritidal) marine dolomitic reservoir. Monitoring during pre-injection, during injection, and post injection will be accomplished with

MVA tools and techniques to visualize $CO_2$ plume movement and will be used to reconcile simulation results. Necessary documentation will be submitted for closure of the small scale carbon storage project.

**Project Goals**

The proposed small scale injection will advance the science and practice of carbon sequestration in the Midcontinent by refining characterization and modeling, evaluating best practices for MVA tailored to the geologic setting, optimize methods for remediation and risk management, and provide technical information and training to enable additional projects and facilitate discussions on issues of liability and risk management for operators, regulators, and policy makers.

The data gathered as part of this research effort and pilot study will be shared with the Southwest Sequestration Partnership (SWP) and integrated into the National Carbon Sequestration Database and Geographic Information System (NATCARB) and the 6th Edition of the Carbon Sequestration Atlas of the United States and Canada.

**Project Deliverables by Task**

1.5 Well Drilling and Installation Plan (Can be Appendix to PMP or Quarterly Report)
1.6 MVA Plan (Can be Appendix to PMP or Quarterly Report)
1.7 Public Outreach Plan (Can be Appendix to PMP)
1.8 Arbuckle Injection Permit Application Review go/no go Memo
1.9 Mississippian Injection Permit Application Review go/no go Memo
1.10 Site Development, Operations, and Closure Plan (Can be Appendix to PMP)
2.0 Suitable geology for Injection Arbuckle go/no go Memo
3.0 Suitable geology for Injection Mississippian go/no go Memo
11.2 Capture and Compression Design and Cost Evaluation go/no go Memo
19 Updated Site Characterization/Conceptual Models (Can be Appendix to Quarterly Report)
21 Commercialization Plan (Can be Appendix to Quarterly Report).
30 Best Practices Plan (Can be Appendix to Quarterly or Final Report)

## ACCOMPLISHMENTS

1. **Continued progress of Milestone 2 (Task 3) --** Site characterization of Mississippian Reservoir for $CO_2$ EOR - Wellington Field.
   - Ran new Petrel model of Mississippian
   - Ran new CMG simulations to refine location of Mississippian $CO_2$ injector
   - Geomodel includes new petrophysical facies for the Mississippian (Mina), and stratigraphic interpretation of Lynn with inverted seismic with both phi and k properties distributed through the model by Jason.

2. **Subtask 1.8 Arbuckle Injection Permit Application** – The permit application consists of 14 chapters (sections). Drafts for all section were completed by KGS on October 10 and forwarded to DOE and Berexco for review. The executive summary of the permit application is included below relay the content.

   The permit document contains an extensive amount of raw, processed, and analyzed technical information along with model simulation results which summarizes the suitability of the Wellington site for conducting not only the small-scale pilot test, but potentially long-term commercial scale carbon capture and sequestration (CCS).

## Milestone Status Report

| Task | Budget Period | Number | Milestone Description |
|---|---|---|---|
| Task 2. | 1 | 1 | Site Characterization of Arbuckle Saline Aquifer System - Wellington Field |
| Task 3. | 1 | 2 | Site characterization of Mississippian Reservoir for CO2 EOR - Wellington Field |
| Task 10. | 2 | 3 | Pre-injection MVA - establish background (baseline) readings |
| Task 13. | 2 | 4 | Retrofit Arbuckle Injection Well (#1-28) for MVA Tool Installation |
| Task 18. | 3-yr1 | 5 | Compare Simulation Results with MVA Data and Analysis and Submit Update of Site Characterization, Modeling, and Monitoring Plan |
| Task 22. | 3-yr1 | 6 | Recondition Mississippian Boreholes Around Mississippian CO2-EOR injector |
| Task 27. | 3-yr2 | 7 | Evaluate CO2 Sequestration Potential of CO2-EOR Pilot |
| Task 28. | 3-yr2 | 8 | Evaluate Potential of Incremental Oil Recovery and CO2 Sequestration by CO2-EOR - Wellington field |

## Project Schedule

Abengoa Biofuels informed us in late July that the Colwich Ethanol Facility would remain shut for the rest of the year because of prior drought in the Midwest and current economics. KGS aggressively engaged in discussions with potential suppliers of anthropogenic $CO_2$ including Praxair, Airgas, Linde, POET Biofuels, Chaparral Energy, and Trenton Agri Products, LLC. Geologic CO2 is not an option for the Wellington project, due to demand for this product along existing pipelines in Texas, New Mexico, Colorado, and Wyoming. Anthropogenic CO2 will be the only viable option for CO2-EOR and as required disposal of the CO2 in the deep saline Arbuckle aquifer below. Berexco is keenly interested in the saline aquifer storage from multiple viewpoints increasingly expressed by others in the petroleum industry – incentives to CO2 suppliers such as enhanced prices for ethanol by sequestration of the CO2 that is injected, obtaining deposal fees to inject CO2 and manage with general operation of the oil field, and with the case at Wellington, obtaining income generated by carbon trading (Biorecro in Sweden).

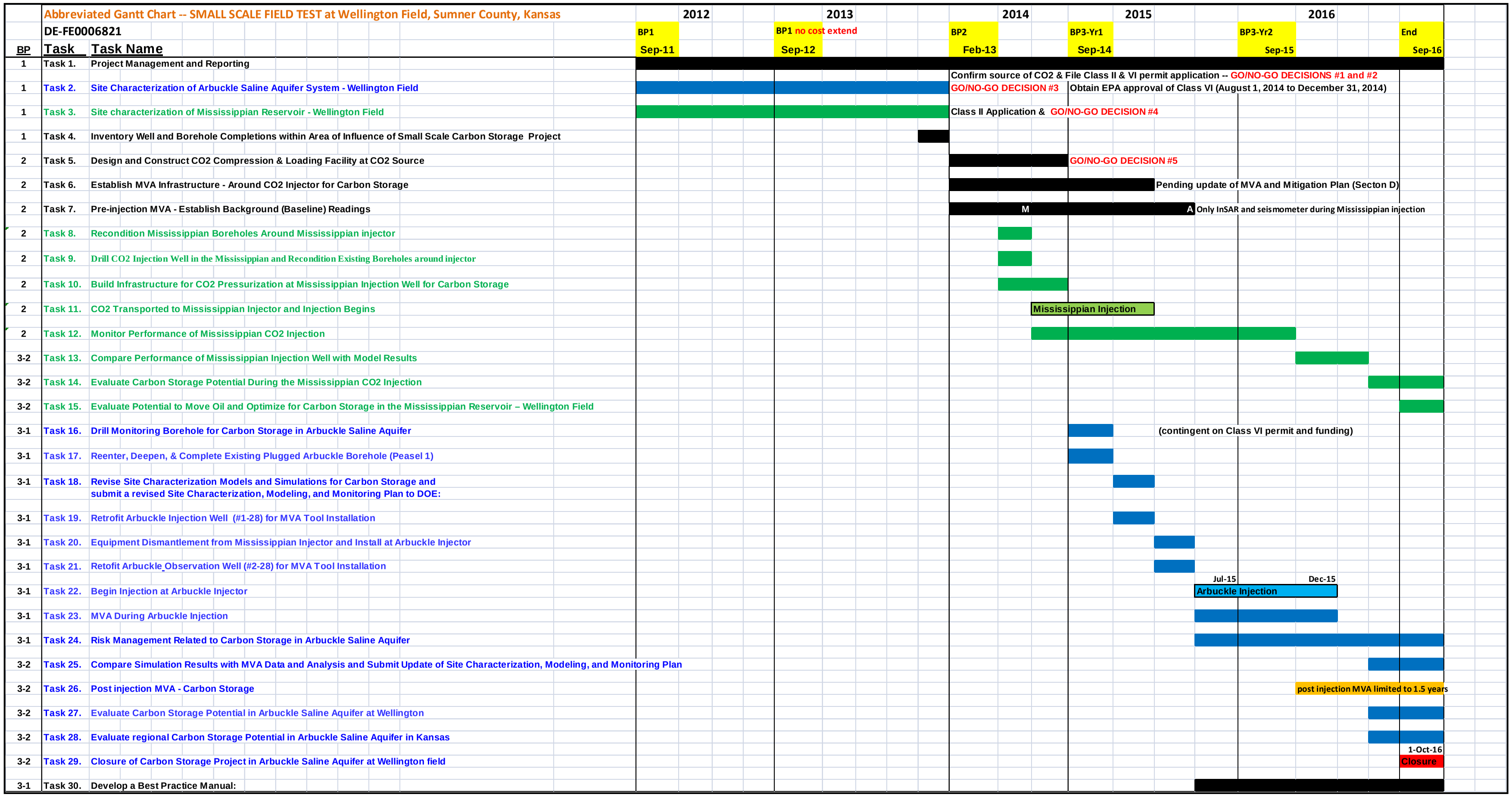
Meetings and conference calls have been held with potential suppliers of CO2 during through September and October. We are currently finalizing quotes for CO2 and are confident that we will have KU contract signed by mid November for one of the suppliers. We will be ready to revise the budget to bring CO2 to Wellington in 2014.

KGS injection at the Wellington site should commence in FY2014 on a schedule depending if the $CO_2$ capture facility will need to be constructed. Our expectation now is that the $CO_2$ will be ready to inject by October 2014. We now plan to first inject into the Mississippian oil and gas reservoir and geomodeling and simulation are well enough along to refine the location and injection schedule.

On October 10, 2013 the Class VI UIC geosequestration permit application was submitted to DOE and Berexco for interval review prior to submitting to EPA. Revised document should be submitted to EPA in December 2013.

A new SOPO was drafted and reviewed by DOE 10/29/13 and will be submitted to DOE for official acceptance once the $CO_2$ source is selected. The Gantt Chart and schedule will also be modified depending on $CO_2$ source and availability of the $CO_2$ for delivery. A decision on the supply by mid November will provide sufficient time to revise the budget and begin Budget Period 2.

A condensed version of the Gantt Chart follows. The PMP and Gantt Chart will be updated as soon as a $CO_2$ source is finalized.



Abbreviated Gantt Chart -- SMALL SCALE FIELD TEST at Wellington Field, Sumner County, Kansas
DE-FE0006821
BP
Task
Task Name
2012
2013
2014
2015
2016
BP1
Sep-11
BP1 no cost extend
Sep-12
BP2
Feb-13
BP3-Yr1
Sep-14
BP3-Yr2
Sep-15
End
Sep-16
1 Task 1. Project Management and Reporting
1 Task 2. Site Characterization of Arbuckle Saline Aquifer System - Wellington Field
1 Task 3. Site characterization of Mississippian Reservoir - Wellington Field
1 Task 4. Inventory Well and Borehole Completions within Area of Influence of Small Scale Carbon Storage Project
2 Task 5. Design and Construct CO2 Compression & Loading Facility at CO2 Source
2 Task 6. Establish MVA Infrastructure - Around CO2 Injector for Carbon Storage
2 Task 7. Pre-injection MVA - Establish Background (Baseline) Readings
2 Task 8. Recondition Mississippian Boreholes Around Mississippian injector
2 Task 9. Drill CO2 Injection Well in the Mississippian and Recondition Existing Boreholes around injector
2 Task 10. Build Infrastructure for CO2 Pressurization at Mississippian Injection Well for Carbon Storage
2 Task 11. CO2 Transported to Mississippian Injector and Injection Begins
2 Task 12. Monitor Performance of Mississippian CO2 Injection
3-2 Task 13. Compare Performance of Mississippian Injection Well with Model Results
3-2 Task 14. Evaluate Carbon Storage Potential During the Mississippian CO2 Injection
3-2 Task 15. Evaluate Potential to Move Oil and Optimize for Carbon Storage in the Mississippian Reservoir – Wellington Field
3-1 Task 16. Drill Monitoring Borehole for Carbon Storage in Arbuckle Saline Aquifer
3-1 Task 17. Reenter, Deepen, & Complete Existing Plugged Arbuckle Borehole (Peasel 1)
3-1 Task 18. Revise Site Characterization Models and Simulations for Carbon Storage and submit a revised Site Characterization, Modeling, and Monitoring Plan to DOE:
3-1 Task 19. Retrofit Arbuckle Injection Well (#1-28) for MVA Tool Installation
3-1 Task 20. Equipment Dismantlement from Mississippian Injector and Install at Arbuckle Injector
3-1 Task 21. Retofit Arbuckle Observation Well (#2-28) for MVA Tool Installation
3-1 Task 22. Begin Injection at Arbuckle Injector
3-1 Task 23. MVA During Arbuckle Injection
3-1 Task 24. Risk Management Related to Carbon Storage in Arbuckle Saline Aquifer
3-2 Task 25. Compare Simulation Results with MVA Data and Analysis and Submit Update of Site Characterization, Modeling, and Monitoring Plan
3-2 Task 26. Post injection MVA - Carbon Storage
3-2 Task 27. Evaluate Carbon Storage Potential in Arbuckle Saline Aquifer at Wellington
3-2 Task 28. Evaluate regional Carbon Storage Potential in Arbuckle Saline Aquifer in Kansas
3-2 Task 29. Closure of Carbon Storage Project in Arbuckle Saline Aquifer at Wellington field
3-1 Task 30. Develop a Best Practice Manual:
Confirm source of CO2 & File Class II & VI permit application -- GO/NO-GO DECISIONS #1 and #2
GO/NO-GO DECISION #3
Obtain EPA approval of Class VI (August 1, 2014 to December 31, 2014)
Class II Application & GO/NO-GO DECISION #4
GO/NO-GO DECISION #5
Pending update of MVA and Mitigation Plan (Secton D)
M
A
Only InSAR and seismometer during Mississippian injection
Mississippian Injection
(contingent on Class VI permit and funding)
Jul-15
Dec-15
Arbuckle Injection
post injection MVA limited to 1.5 years
1-Oct-16
Closure

**Activities of Lawrence Berkeley National Lab**

No work has been completed or funds expended during this quarter by LBNL.

## ONGOING ACTIVITIES –

## TASK 1. PROJECT MANAGEMENT AND REPORTING

### Subtask 1.8. Arbuckle Injection Permit Application

#### Permit Status and Activities

The table below is undergoing weekly updates to inform DOE on the status of the $CO_2$ supply and permits to drill Arbuckle and Mississippian wells.

| Schedule for DE-FE0006821 - Contracting new CO2 source, rescheduling with revised budget and SOPO | %COMPLETION | |
|---|---|---|
| 1) Complete negotiations by Dana Wreath (Berexo) and KGS with CO2 suppliers to receive final bids for the CO2, ensuring reliable safe delivery, maximize volume of CO2, option to be involved in the onsite injection | 90% | |
| September 6, 2013 (best); ~~October 6 (worst)~~ November 15 with KU contract | | |
| 2) Complete DOE budget review of CO2 costs and revise Berexco subcontract completed via a 9.2 form; formalize schedule and update SOPO and Gantt Chart | 10% | |
| October 30, 2013 (best); ~~November 30, 2013 (worst)~~ beginning November 18 | | |
| 3) Obtain Class II permit to inject CO2 into the Mississippian | 50% | |
| September 30, 2013 (best); November 30, 2013 (worst) | | |
| 4) Obtain permission from DOE to commence field activities – drill Mississippian injection well (**revised BP2**) | | |
| November 15, 2013 (best); December 1, 2013 | | |
| 5) Begin drilling of Mississippian injection well | | |
| ~~December 1, 2013 (best); February 1, 2014~~ after February 1, 2014 with start of BP2 and negotiated budget | | |
| 6) Establish surface facilities to inject CO2 and complete MVA activities slated for the Mississippian (InSAR, passive seismic, sample fluids from production wells in 5-spot) | | |
| March 1, 2014 (best); April 1, 2014 (worst) | | |
| 7) Begin injection of CO2 into the Mississippian | | |
| April 1, 2014 (best); June 1, 2014 (worst) October 1 '14 (~~with mobility control~~) October 1 if skid is built | | |
| 8) Complete injection in the Mississippian | | |
| January 1, 2015 (best); March 1, 2015 (worst) July 30, 2015 (~~with mobility control~~) | | |
| 9) Submit Class VI permit to EPA to inject into Arbuckle | | |
| November 1, 2013 (best), December 31st, 2013 (worst) -- submitted to DOE and Berexco 10/10/13 | | |
| 10) Obtain Class VI permit to inject into Arbuckle | | |
| August 1, 2014 (best), December 31, 2014 (worst) | | |
| 11) Drill observation well into Arbuckle | | |
| October 1, 2014 (best), March 1, 2015 (worst) | | |
| 12) Install MVA equipment in observation well | | |
| November 1, 2014 (best), April 1, 2015 (worst) | | |
| 13) Install shallow and deep groundwater monitoring wells | | |
| September 1, 2014 (best), March 1, 2015 (worst) | | |
| 14) Begin injection of CO2 into the Arbuckle saline aquifer | | |
| February 1, 2015 (best), July 1, 2015 (worst) August 1, 2015 (~~with mobility control~~) | | |
| 15) Complete injection of CO2 into the Arbuckle saline aquifer (20k tonnes of CO2) | | |
| October 1, 2015 (best), January 1, 2016 (worst) | | |
| 16) Complete post injection monitoring of the Arbuckle | | |
| August 1, 2015 (best), October 1, 2016 (worst) | | |
| 17) Run repeat 3D seismic survey over Arbuckle injection site | | |
| August 1, 2015(best), October 1, 2016 (worst) | | |
| 18) Apply for closure of the Arbuckle injection site | | |
| August 1, 2016 (best), October 1, 2016 (worst) | | |
| 19) Project end. | | |
| September 30, 2016 (best), February 1, 2017 (worst) | | |

The draft of the Executive Summary of the Class VI application is included here to show the basis of the application that is being internally reviewed.

## Draft Executive Summary

A small scale pilot carbon capture and storage (CCS) project is proposed by Berexco, Inc and Kansas Geological Survey at the Wellington oilfield approximately four miles northwest of the City of Wellington in Sumner County, Kansas (Figure ES-1). The project is part of a US Department of Energy (DOE) funded pilot scale study to demonstrate the ability of the 4,000 feet deep Cambrian-Ordovician age Arbuckle saline aquifer to accept and retain carbon dioxide ($CO_2$) for permanent geologic sequestration. Approximately 40,000 tons of anthropogenic $CO_2$ is to be injected in the Arbuckle aquifer over a period of 9 months. The details of the project and EPA Underground Injection Control (UIC) Class VI construction, operations, monitoring, well plugging, Area of Review (AoR), post-injection site care and site closure, emergency remedial/response, and financial responsibility plans are summarized below.

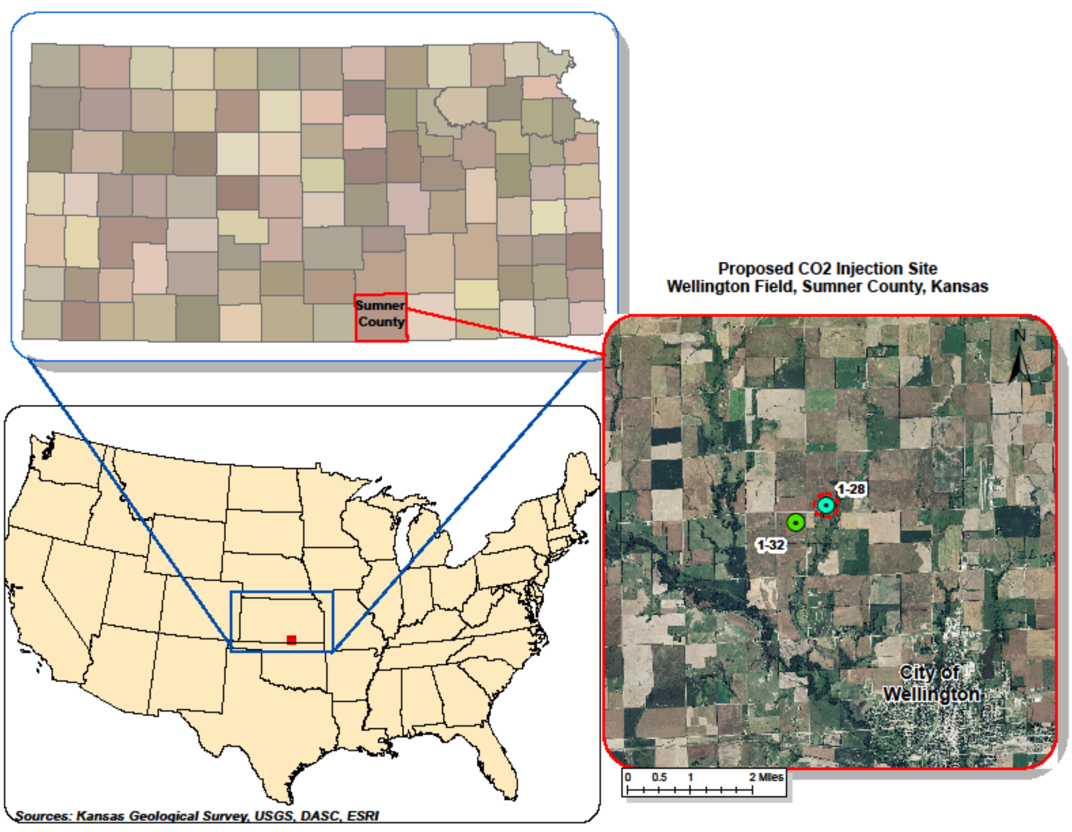



Figure ES-1 *Location of small-scale CO2 storage site at Wellington, Kansas*

## Site Setting

The Wellington sequestration site is located in a rural area where land is used primarily for (non-irrigated) crop cultivation (Figure ES-2). $CO_2$ injection is to occur at the recently completed well (KGS 1-28) which was constructed per EPA UIC Class VI specifications. There are no potable water wells in the vicinity of the injection well. The EPA AoR based on the maximum extent of plume migration is only 1,750 feet from the well as shown in Figure ES-2.

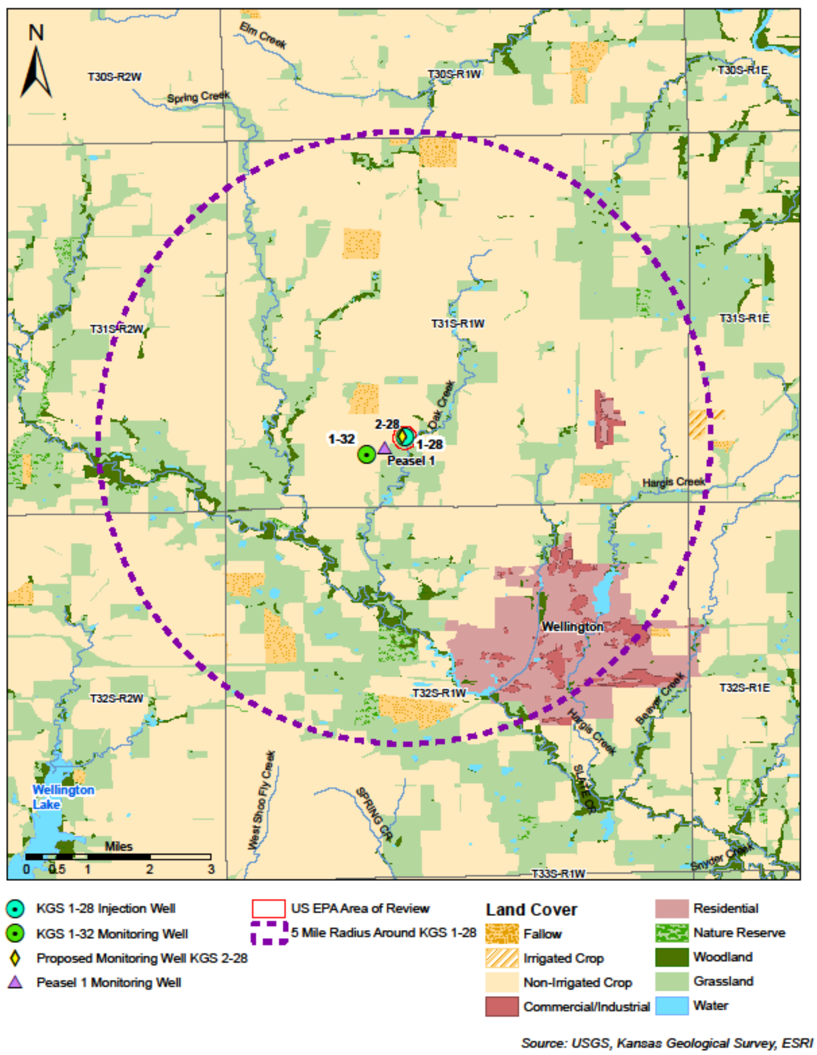



Figure ES-2 Land use in the vicinity of the Wellington small-scale $CO_2$ storage site

## Geology

### Arbuckle Group (Injection Zone)

The geologic column at the injection well site is presented in Figure ES-3. The injection is to occur in the 1,000 ft thick regionally extensive Arbuckle Group of Cambrian-Ordovician period located approximately 4,160 feet below ground at the Wellington site. The injection is to occur near the base of the Arbuckle Group, which has relatively higher permeability as compared to the rest of the formation.

### Simpson Group/Chattanooga Shale/Pierson Formation (Upper Confining Zone)

The Ordovician and Devonian shales within the Simpson Group and Chattanooga Shale, along with the argillaceous siltstone in the Pierson Formation of Mississippian subsystem, have the characteristics of caprock and will therefore function as the top confining zone and effectively prevent upward migration of $CO_2$. The 240 feet thick confining zone has a minimum number of communicative fractures. There are several thick layers of shale above the upper confining zone as well as shown in Figure ES-3, which can potentially provide additional impedance to flow, but which are not relied in this application to demonstrate confinement potential.

### Precambrian Granitic Basement (Lower Confining Zone)

Precambrian-age basement granites underlie the Arbuckle Group throughout Kansas, and are expected to provide hydraulic confinement at the base of the injection zone.

### Upper Wellington Formation (USDW)

The lowermost and only Underground Sources of Drinking Water (USDW) extends from land surface to 250 feet below ground and comprises of Permian shales in the Upper Wellington Formation as shown in Figure ES-3. Below the Upper Wellington are the Hutchinson Salt Beds which overlies bedrock shales in the Lower Wellington Formation. The USDW (Upper Wellington formation) lies approximately 4,500 feet above the top of the injection zone in the lower

Arbuckle aquifer. There are no groundwater withdrawals in the vicinity of the Wellington $CO_2$ storage site.

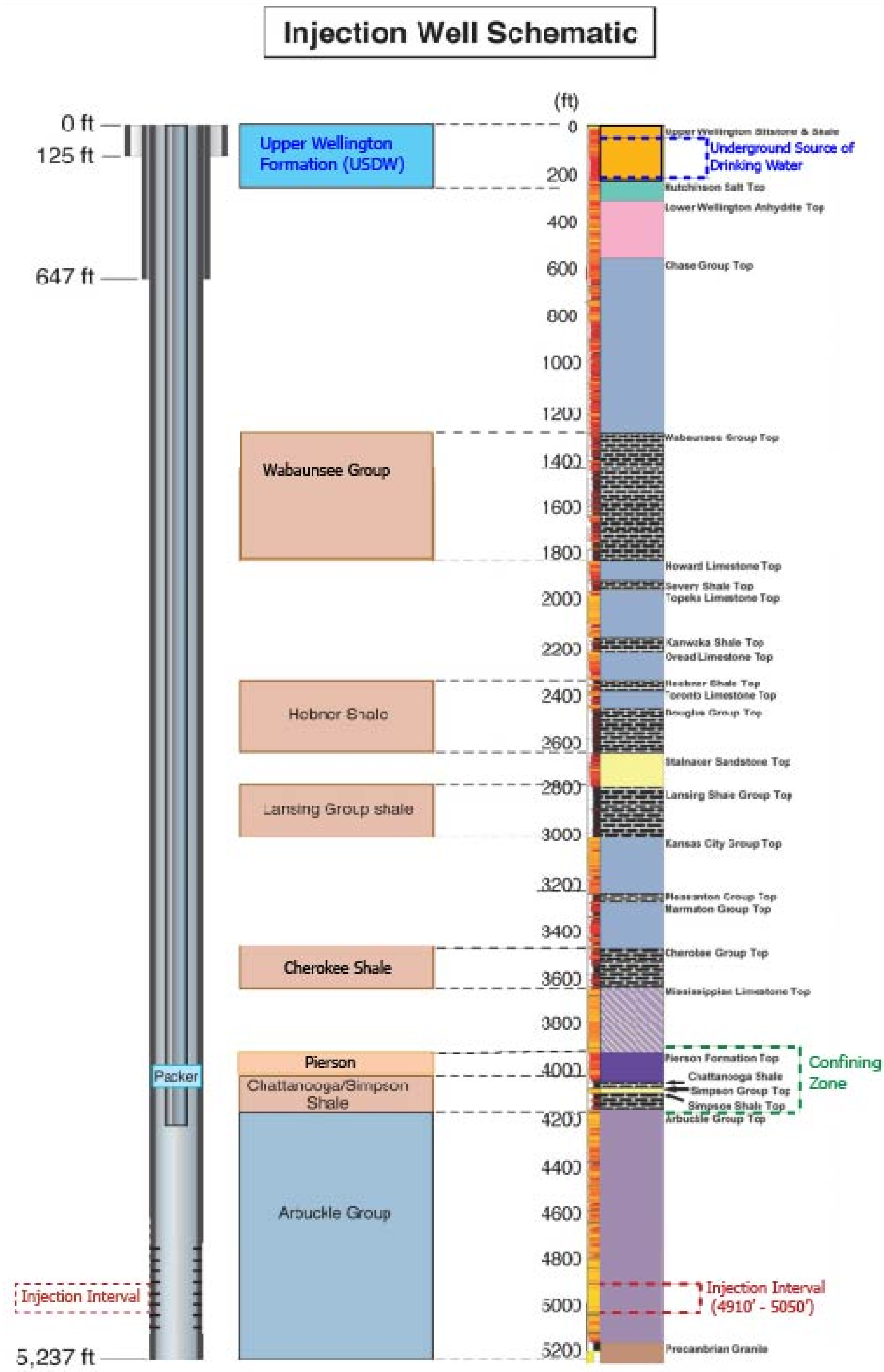


Figure ES-3 Schematic of injection well showing geologic formations at Wellington sequestration site *(Jennifer to prepare better figure and also show Injection Zone and Precambrian basement*).

## Estimated Sequestration Capacity of Arbuckle Group

The total amount of $CO_2$ that could be stored in the Arbuckle Group within Kansas is estimated by the US DOE to be as high 89.5 billion metric tons, the equivalent of several years of annual $CO_2$ emissions (approximately 6 billion metric ton/year)for the entire United States. Approximately 300,000-360,000 metric tons of $CO_2$ per square mile can be stored in the Arbuckle aquifer at the Wellington site as shown in Figure ES-4. Only 40,000 tons of $CO_2$ will be injected into the Arbuckle during a period of 9 months, which as per DOE estimates should be stored in an area of 1/10$^{th}$ of a square mile.

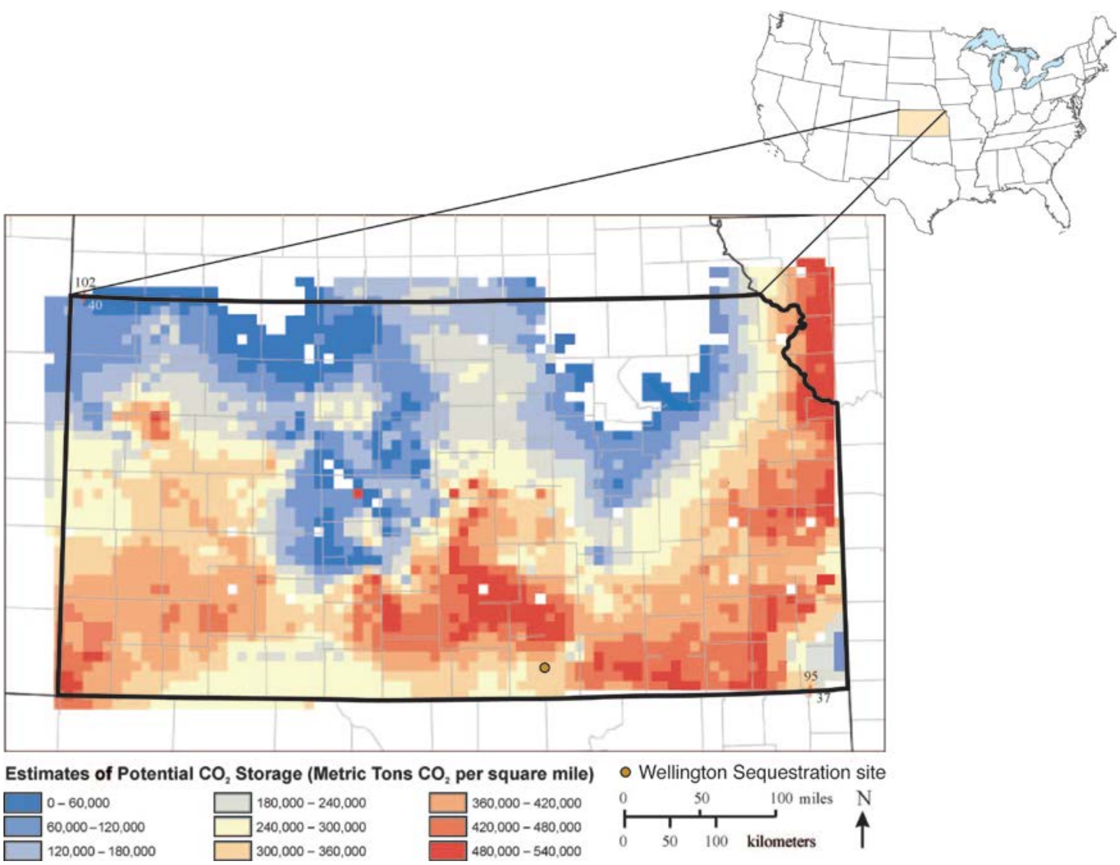



Figure ES-4 Map showing the estimated sequestration potential in the Arbuckle saline aquifer in metric tons $CO_2$ per square mile.

## Modeling

During construction of the injection well (KGS 1-28) and the geologic characterization well (KGS 1-32) shown in Figure ES-1, an extensive suite of geophysical logs were obtained to understand the geology and hydrogeology, and derive petrophysical properties. The data was used to develop a reservoir simulation model of the Arbuckle Group. An extensive set of computer simulations were conducted using the base case model and nine alternative models in order to account for parametric uncertainty and to bracket the impacts of $CO_2$ injection on subsurface fluid pressures and extent of $CO_2$ plume migration. The underlying motivation was to determine if the injected $CO_2$ could negatively impact the USDW, or potentially escape into the atmosphere through existing wells or faults/fractures that may either be present, reactivated, or created by the injected fluid.

Simulation results indicate that the maximum pressure induced in the Arbuckle aquifer are insufficient to cause vertical migration of the brines into the USDW due to under-pressurization of the Arbuckle aquifer. The (pre-injection) heads in the Arbuckle injection zone are approximately 600 feet lower than heads in the USDW. Simulation results also indicate that the pressures induced due to injection will dissipate within three months of cessation of injection. Also, the maximum pressure induced at the top of the Arbuckle are insufficient to cause Arbuckle fluids to migrate upward due to the high entry pressure of the confining zone.

Simulations results also indicate that the $CO_2$ will largely remain confined in the lower Arbuckle injection zone and not migrate even into the mid-Arbuckle (Figure ES-5a). Laterally, the maximum extent of the plume is expected to be approximately 1,750 feet from the injection well as shown in Figure ES-5b, and the plume growth is expected to cease in less than a year of cessation of injection. Therefore, a post-injection monitoring period of one year is proposed as indicated below.

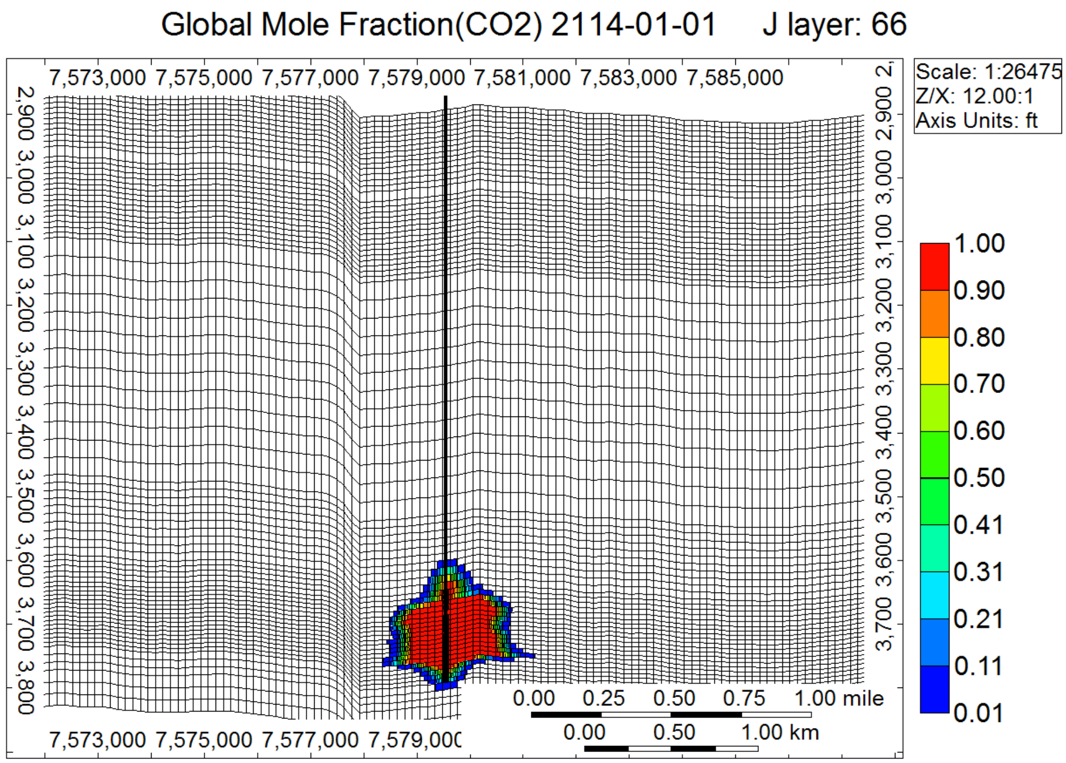



Figure ES-5a Vertical extent of $CO_2$ plume migration at the end of 100 years following injection (Jenn to improve figure and also show the injection interval and other Arbuckle zones).

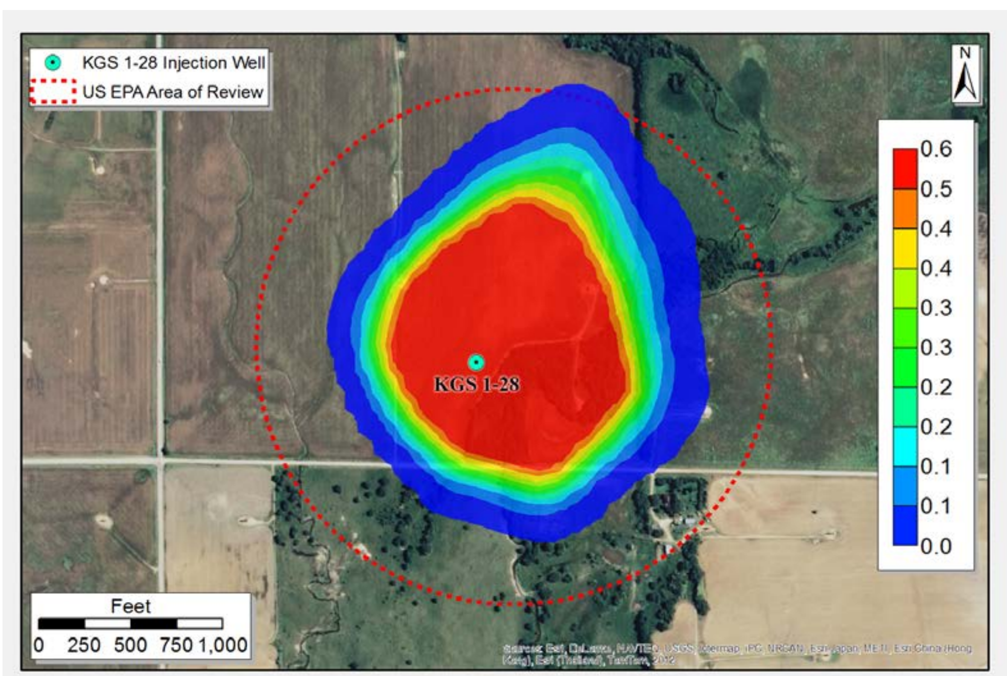



Figure ES-5b Maximum extent of $CO_2$ plume migration (Jenn to improve figure and also show 2-28 and 1-32).

## AoR and Corrective Action

The EPA AoR derived for the Wellington project is based on EPA's *Maximum Extent of the Separate-phase Plume or Pressure-front (MESPOP)* methodology. It was determined that the pressures to be induced due to injection of $CO_2$ at Wellington are insufficient to cause brines from the Arbuckle Group to migrate vertically into the USDW through any natural or artificial penetration. Therefore, the AoR is based on the maximum extent of plume migration, which as shown in Figure ES-5 extends approximately 1,750 feet from the injection well. There are no existing or abandoned wells (other than the proposed injection well) either in the Arbuckle Group or the overlying confining zone within the AoR. Therefore, no well corrective action is required.

Following commencement of injection, if significant deviations in the projected formation pressures and plume migration patterns are observed, then the reservoir model may be recalibrated which will trigger an automatic revaluation of the AoR and Corrective Action Plan. This iterative process may continue until field based observations and model projections are in agreement.

## $CO_2$ Compatibility in Injection Zone and Well

Geochemical analyses suggests that the injection of anthropogenic $CO_2$ should not cause any compatibility problems with formation waters and minerals in the Arbuckle Group, which could result in reduced pore space, excessive formation/well pressures, or any hindrance to injection operations or geologic storage.

The tubing, casing, packer, and cement of the injection well are also designed for $CO_2$ injection operations. The chemical composition of the injectate should cause no adverse reactions or degradation of the well components for the short nine month duration of injection. The low water content of the injected $CO_2$ and the low temperatures will result in only a mildly corrosive environment. Quarterly monitoring for corrosion using coupons however is to be conducted in order to provide early warning of a deteriorating environment.

## Testing and Monitoring Plan

A total of five monitoring wells will be used for tracking the $CO_2$ plume and pressure front. The locations of these monitoring wells and the formations they will monitor are shown in Figure ES-6. One monitoring well is located in the Arbuckle aquifer. Two existing Mississippian wells will be used to check if $CO_2$ has escaped upward from the primary confining zone (base of Simpson Group to top of Pierson Formation) at the site. Two shallow wells will monitor water quality in the Upper Wellington Formation (lowermost USDW). Both direct and indirect measurement methods will be used to monitor the movement of the pressure and plume fronts, identify potential risks to USDWs, and to verify predictions of plume movement.

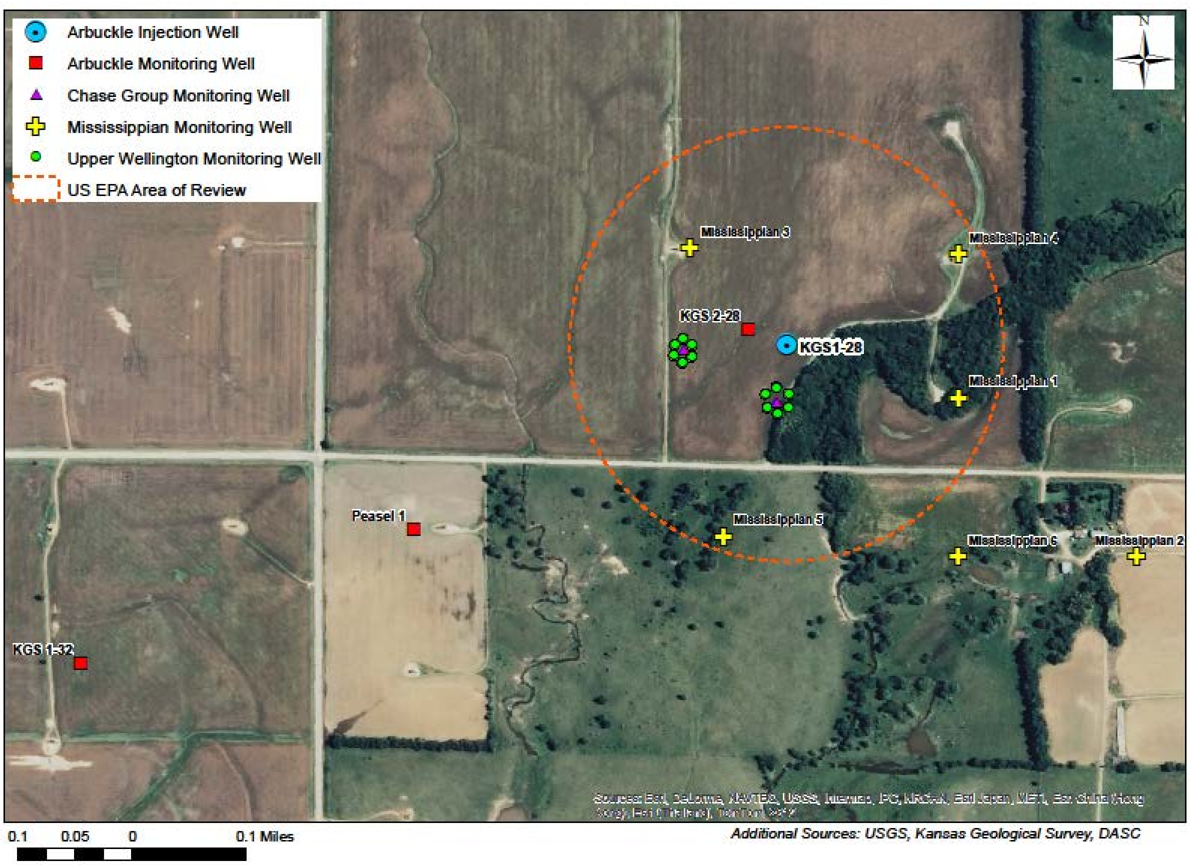



Figure ES-6 Location of monitoring wells in the Arbuckle, Mississippian, and Wellington formations (Jenn to only show final wells that have been selected).

## Injection Well Monitoring

The surface and bottomhole pressures and temperatures will be monitored continuously at the injection well. The chemical composition of the injectate will be tested quarterly in order to ensure that it does not qualify as hazardous waste with regard to corrosivity or toxicity. Due to the short nine month period of injection, corrosion is not expected to occur in the Wellington injection or observation wells. However, corrosion coupons will be used for monitoring loss of material in the Arbuckle injection and monitoring wells on a quarterly basis.

Internal and external Mechanical Integrity Tests (MITs) will be conducted prior to, during, and following injection. Temperature logs will be used to demonstrate external MIT. Prior to commencing injection, an Annulus Pressure Test will also be conducted at the injection well in order to demonstrate internal MIT. The test will provide information necessary to determine whether there is a failure of the casing-cement bond, injection tubing, and packers.

A pre-injection pressure fall-off test will be conducted in order to estimate formation properties in the vicinity of the injection well. This information will serve as a baseline in the event of any changes in the near-wellbore environment that may impact injectivity and result in pressure increases.

## Pressure Front Monitoring

Pressure transducers will be installed in the Arbuckle injection and monitoring wells (KGS 1-28 and KGS 2-28). The acquired pressure data will be compared with model based prediction of the pressure front, and if necessary, the simulation model will be recalibrated to conform to field data. In addition to direct monitoring, the pressure front will also be tracked areally by monitoring surface deformation using InSAR (Interferometric Synthetic Aperture Radar) remote sensing technique.

## Monitoring the Plume Front

Various direct and indirect MVA tools and techniques shall be used to monitor the plume front. The crosswell tomography, U-tube, and continuous active source seismic monitoring (CASSM) technology shall be used to monitor and visualize the movement of the $CO_2$ plume. Sampling and analysis of water and casing head gas from existing Mississippian wells/boreholes around the Arbuckle injector shall be used to determine if injected $CO_2$ has breached the confining zone and escaped into the overlying Mississippian Reservoir. Shallow groundwater sampling and analysis will help confirm if any injected $CO_2$ has reached the USDW. The newly acquired data will be compared with the existing baseline seismic data in order to track the plume movement. The monitored data will also be used revise the simulation model, update site characterization, and potentially revise the monitoring plan if deemed necessary.

A 3-D seismic survey will also be undertaken prior to closure, in order to validate the absence of $CO_2$ outside the containment strata and confirm that future leakage risks are minimal to non-existent.

## Geomechanical Failure and Seismic Risk

Simulation results indicate that the pressures induced due to $CO_2$ injection at KGS 1-28 are insufficient to initiate new fracture, propagate existing fractures, or cause slippage along any existing fault planes. There are no documented faults in the vicinity of the injection well, with the closest fault approximately 12.5 miles southeast of the site where negligible pressures will be induced due to injection. The Wellington storage site (and all of Kansas) is in a low seismic hazard area as defined by the United States Geological Survey. Historical record indicates that most earthquakes in Kansas are small with the largest measured at 4.0 on the Richter scale, which is not of sufficient strength to cause any infrastructure damage.

## $CO_2$ Trapping Potential of the Mississippian Oil Field

The Mississippian oil reservoir lies immediately above the primary upper confining zone. It is a highly under-pressurized system which is likely a consequence of oil and gas production that has occurred in this formation since the early 1900s. Due to this under-pressurization, any $CO_2$ that may escape from the primary confining zone is likely to be trapped in the Mississippian formation. This under-pressurization could not have existed in the absence of a competent low permeability confining zone between the Arbuckle and the Mississippian systems, which essentially provides a hydraulic seal between the two formations.

## Injection Well Construction

The 5,241 ft deep injection well (KGS 1-28) penetrates the top of the pre-Cambrian basement rock at a depth of approximately 5,160 feet. The well will be perforated between 4910 – 5050 feet for injection into the highly permeable lower Arbuckle zone as shown in Figure ES-3. The injection well was constructed in accordance with UIC Class VI construction guidelines using $CO_2$ resistant cement and corrosion resistant material in the production casing and injection tubing. The tubing and the casing are designed to withstand axial, burst, and collapse stresses. Cement bond and variable density logs were acquired after setting and cementing the surface casing and long-string casing. These logs do not indicate any loss of mechanical integrity.

## Injection Well Plugging Plan

The injection well and potentially the Arbuckle monitoring well (KGS 2-28) will be plugged as per UIC Class VI specifications to the top of the Pierson Formation, which corresponds to the top of the confining zone. Both wells may be used in the future for $CO_2$ Enhanced Oil Recovery (EOR) injection or other oilfield operations in the locally producing Mississippian formation, so plugging will only occur to the base of the intended oil recovery zone (top of Pierson Formation). The Arbuckle monitoring well KGS 2-28 will be plugged as a Class VI well in the event that the $CO_2$ plume reaches this well, or is expected to reach this well at any time in the future.

## Surface Facilities and Operations

The planned volume of $CO_2$ injection is 150 tonnes per day. The $CO_2$ will be transported to the site in trucks in liquid state at a pressure of approximately 250 pounds per square inch (psi) and temperature of -10$^{o}$ F. The surface facilities at the Wellington injection site will consist of a storage tank, a pump, a programmable logic controller (PLC), and wellhead. The bottomhole and wellhead pressures and temperatures will be continuously monitored along with the flow rate and the data fed continuously to the PLC. The PLC will manipulate the control valve in order to not exceed the maximum specified flow rate and to ensure that the bottom hole pressure in the injection well does not exceed the maximum allowable pressure, which corresponds to 90% of the fracture pressure. The PLC will be programmed to initiate shutdown if the operating ranges are exceeded.

## Post Injection Site Care and Site Closure Plan (PISC)

Due to the expected stabilization of the pressure and plume fronts in less than a year following cessation of injection, it is proposed that site be closed one year after cessation of injection. Upon cessation of injection, the most recently acquired field data will be used to refine the reservoir model if necessary, and update simulation results and the projected pressure front and plume movement. The revised projections will be used to determine whether the monitoring, AoR, and PISC plans are adequate to ensure accurate tracking of the plume/pressure front and support closure of the site. If necessary, this process of data acquisition and model refinement/projections may continue in order to determine whether or not the injected $CO_2$could migrate out of the storage formation into the USDW. Once a determination of no negative impacts to the USDW is made, an application for site closure will be filed with the EPA Director.

## Emergency Remedial Response Plan

An Emergency Remedial Response Plan has been prepared and will be implemented if Berexco obtains evidence that the injected $CO_2$ stream and/or associated pressure front may endanger the USDW. Specific plans are outlined for a variety of emergency conditions related to testing, monitoring, and mechanical failure. The plans involve immediate cessation of injection, identification and characterization of the failure, notification of the EPA UIC Program Director within 24 hours, and implementation of the appropriate response and remedial action. In addition to executing an automatic shutdown, the PLC will also notify Berexco of a shutdown over cellular network.

## Financial Responsibility Plan

Due to its extensive experience in subsurface oil and gas operations and strong financial position, Berexco, is opting for the self-insurance option to demonstrate Financial Responsibility to carry out $CO_2$ storage activities related to performing well corrective action, injection well plugging, post-injection site care, site closure and implementing an emergency/remedial plan . Berexco meets or exceeds all minimum financial coverage criteria to demonstrate financial strength and ability to complete sequestration activities. It should also be noted that the Wellington projected is part of a cooperative agreement with the US DOE. The US DOE has obligated approximately 11 million dollars for this project. Therefore, financial risks to Berexco are minimal.

## Conclusions and Risks to USDW

Detailed AoR, Construction and Operations, Testing and Monitoring, Injection Well Plugging, Post-Injection Site Care and Site Closure, Emergency and Remedial Response, and Financial Responsibility plans have been prepared and documented in this application to fulfill all 40 CFR Part 146 requirements for developing and operating a Class VI $CO_2$ geologic sequestration project.

The modeling based projections for the small-scale pilot project indicate that the subsurface pressures induced due to $CO_2$ injection will be insufficient to cause vertical migration of brines from the injection zone into the USDW. Additionally, the injected $CO_2$ is expected to be contained within the injection zone in the lower portions of the Arbuckle, and the plume to stabilize within one year of cessation of injection. Therefore, risk of contamination of the USDW from injection operations at Wellington is minimal.

**--- end of Executive Summary --**

**Subtask 1.9 Mississippian Injection Permit Application**

Petrel model of Mississippian updated week of 9/23/14 and will run CMG simulation after that/use to refine location of Miss CO2 injector

9/30/13 geomodel has integrated petrophysical facies for the Mississippian (Mina), and stratigraphic interpretation of Lynn with inverted seismic with both phi and k distributed

10/11/13 - CMG simulation underway and initial results to be presented next week

10/29/13 -- Initial simulations by Eugene and more to come to use in confirming location of Mississippian injection well

### Key Findings

1. We have a portfolio of viable CO2 suppliers, one whom will provide CO2 to Wellington Field. Contacts will be maintained with other suppliers as part of continuing discussions on handling anthropogenic CO2 in Kansas.
2. The Class VI geosequestration permit application has met fundamental guidelines of EPA and the document provides a clear representation of this information needed for an expeditious review toward approval of the small scale field test.

**Plans**

1. Complete negotiations, select CO2 supplier, and negotiate the budget in next quarter so that BP 2 and field activities can begin on February 1, 2014.
2. Finalize refined model of the Mississippian so that Mississippian Injection Permit Application can be submitted.
3. Submit application for Class VI injection permit to the EPA in next quarter.
4. Submit updated management plan, SOPO and Gantt Chart with selection of CO2 source.
5. Submit well drilling and installation plan, MVA plan, Public Outreach Plan based on material included in Class VI application as part of next quarterly report.

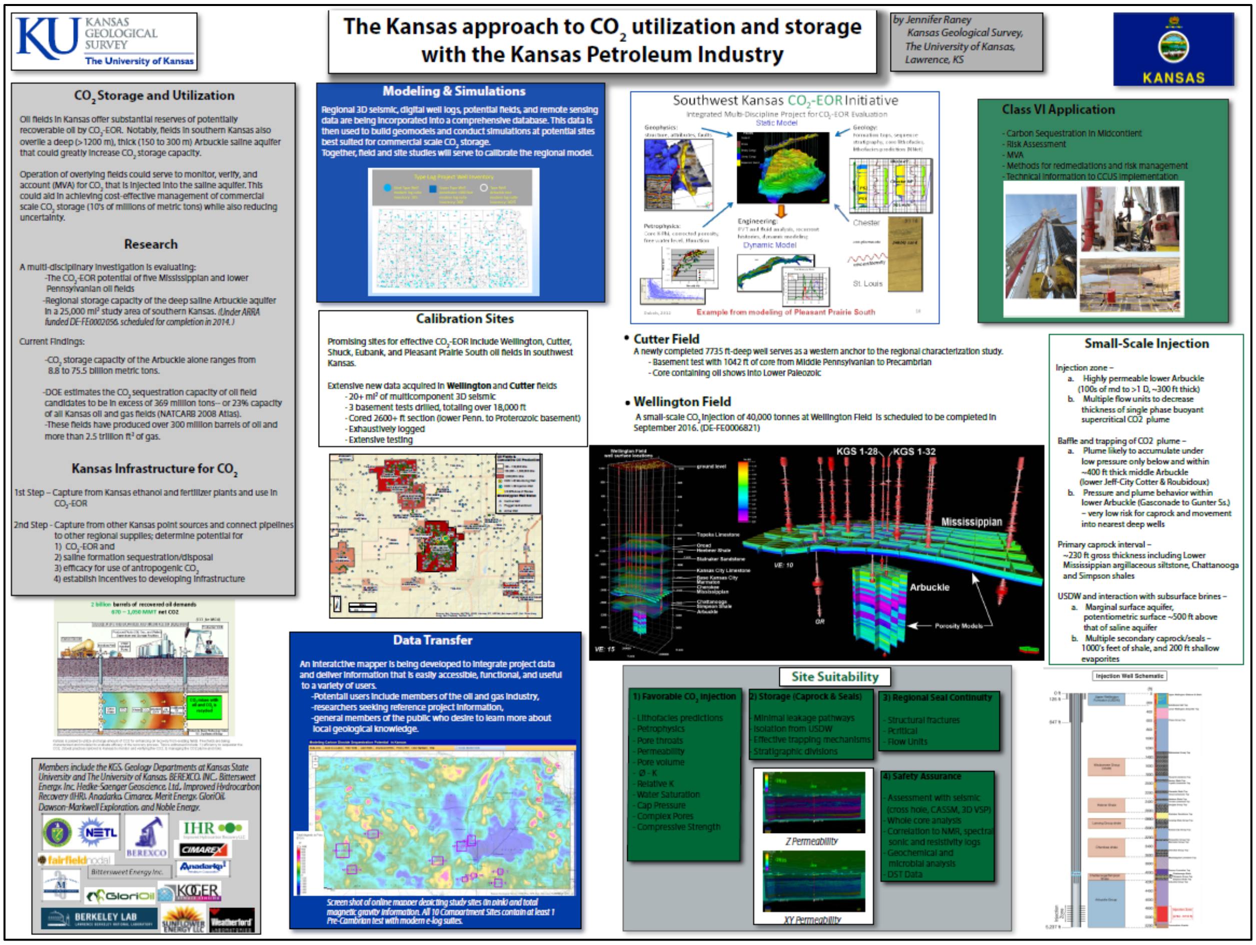
## PRODUCTS

**Publications, conference papers, and presentations**

**DOE Annual review meeting, August 20 & 21, 2013, Pittsburgh, PA**

W. Lynn Watney and Jason Rush, Joint PIs, 2013, *Small scale field test demonstrating CO2 sequestration in Arbuckle saline aquifer and by CO2-EOR at Wellington field, Sumner County, Kansas DE-FE0006821*.
http://www.kgs.ku.edu/PRS/Ozark/Reports/2013/Watney_DE-FE0006821_FY13_Carbon_Storage_Review_v3.pdf

Jennifer Raney, 2013, *The Kansas approach to CO2 utilization and storage with the Kansas petroleum industry*. (see below)




**Presentations, Midcontinent AAPG**

Brent Campbell, 2013, Geochemical assessment of secondary oil recovery, and assessing potential quantification of CO2 sequestration in the underlying saline Arbuckle aquifer, AAPG Mid-Continent Section Meeting, Wichita.

John Doveton, 2013, Pore size and textural analysis of carbonates from nuclear magnetic resonance logging : an Arbuckle case study, AAPG Mid-Continent Section Meeting, Wichita.

Yevhen Holubnyak, 2013, Reservoir Engineering Aspects of Pilot Scale CO2 EOR Project in Upper Mississippian Formation at Wellington Field in Southern Kansas, AAPG Mid-Continent Section Meeting, Wichita.

Yevhen Holubnyak, 2013, Dynamic Modeling of CO2 Geological Storage in the Arbuckle Saline Aquifer, AAPG Mid-Continent Section Meeting, Wichita.

W. Lynn Watney, 2013, Seismic attribute analysis of the Mississippian chert at the Wellington Field, south-central Kansas, AAPG Mid-Continent Section Meeting, Wichita.

W. Lynn Watney, 2013, Evaluating CO2 Utilization and Storage in Kansas, AAPG Mid-Continent Section Meeting, Wichita.

## PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

A project organization chart follows. The work authorized in this budget period includes office tasks related to preparation of reports and application for a Class VI permit to inject CO2 into the Arbuckle saline aquifer. Tasks associated with reservoir characterization and modeling are funded in contract DE-FE0002056.

**ORGANIZATION CHART**

| Name | Project Job Title | Primary Responsibility |
|---|---|---|
| **Kansas Geological Survey** | | |
| Lynn Watney | Project Leader, Joint Principal Investigator | Geology, information synthesis, point of contact |
| Yevhen Holubnyak | Petroleum Engineer | Reservoir engineer, dynamic modeling, synthesis |
| Jason Rush | Joint Principal Investigator | Geology, static modeling, data integration, synthesis |
| John Doveton | Co-Principal Investigator | Log petrophysics, geostatistics |
| Dave Newell | Co-Principal Investigator | Fluid geochemistry |
| Rick Miller | Geophysicist | 2D seismic acquire & interpretation |
| | | LiDAR/InSAR support, water well drilling/completion |
| TBN | Geology Technician | Assemble and analyze data, report writing |
| Tiraz Birdie | President, TBirdie Consulting, Inc. | Hydrogeologic modeling, permitting, MVA, integration |
| **KU Department of Geology** | | |
| Michael Taylor | Co-Principal Investigator | Structural Geology, analysis of InSAR, LiDAR, seismometer array |
| TBN | Graduate Research Assistant | Structural Geology, analysis of InSAR and LiDAR, seismometer array |
| **Kansas State University** | | |
| Saugata Datta | Principal Investigator | |
| TBN | Graduate Research Assistant | Aqueous geochemistry |
| TBN | 3- Undergraduate Research Assistants | |
| **Lawrence Berkeley National Laboratory** | | |
| Tom Daley | Co-Principal Investigator | Geophysicist, analysis of crosshole and CASSM data |
| | | Hydrogeology, analysis of soil gas measurements |
| Barry Freifeld | Co-Principal Investigator | Mechanical Engineer, analysis of U-Tube sampler |
| **Sandia Technologies, Houston** | | |
| Dan Collins | Geologist | Manage CASSM and U-Tube operation |
| David Freeman | Field Engineer | Manage field install of CASSM and U-Tube |
| **Berexco, LLC** | | |
| Dana Wreath | VP Berexco, LLC | Engineering, Manager of Wellington Field |
| Randy Koudele | Reservoir engineer | Engineering |
| Staff of Wellington Field | | Field operations |
| Beredco Drilling team | | Mississippian and Arbuckle drilling operations |
| **Abengoa Bioenergy Corp.** | | |
| Christopher Standlee, Danny Alllison | | CO2 supply Colwich Ethanol Facility |

## IMPACT

The project has been discussed in public venues – presentations at professional meetings, legislative committees, and town hall meeting, and has provided information on the project via the website to encourage a dialog on the merits and economies related to carbon management in Kansas. Kansans are realizing the potential for an important collaboration between the two of the largest economies in Kansas – agriculture and related ethanol industry and the petroleum industry to advance energy and contribute to a viable rural economy.

The small scale field test at Wellington Field as designed integrates two petroleum business activities: 1) use of $CO_2$ for enhanced oil recovery and revitalizing many older mature oil fields and 2) disposal/storage of $CO_2$ in the underlying saline aquifer for the longer term. It has been conveyed to the local petroleum industry that drilling and oil production infrastructure of an active oil field are important components that could lead to a successful carbon sequestration project including 1) knowledge about the subsurface including injection zones and caprock, 2) knowledge about abandoned wells, 3) access and suitability of land with greater likelihood for participation by landowner, and 4) access to insurance and investors to facilitate economic success.

## CHANGES/PROBLEMS

KGS is committed to starting BP2 on February 1, 2014 with a new $CO_2$ supplier on board and beginning field activities to inject $CO_2$ into the Mississippian reservoir.

## BUDGETARY INFORMATION

### Cost Status Report

See next page for the cost status for quarters 1-8.

**COST PLAN/STATUS**

| | BP1 Starts: 10/1/11 | | Ends: 1/31/14 | | | | | |
|---|---|---|---|---|---|---|---|---|
| Baseline Reporting Quarter | 10/1/11-12/31/11 Q1 | 1/1/12-3/31/12 Q2 | 4/1/12-6/30/12 Q3 | 7/1/12-9/30/12 Q4 | 10/1 /12- 12/31/12 Q5 | 1/1/13 - 3/31/13 Q6 | 4/1/13 - 6/30/13 Q7 | 7/1/13-9/30/13 Q8 |
| **Baseline Cost Plan (from SF-424A)** | (from 424A, Sec. D) | | | | | | | |
| Federal Share | $326.84 | $17,208.52 | $17,282.92 | $31,693.50 | $23,000.00 | $23,000.00 | $23,000.00 | $23,000.00 |
| Non-Federal Share | $365,421.00 | $365,421.00 | $365,421.00 | $365,421.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| Total Planned (Federal and Non-Federal) | $365,747.84 | $382,629.52 | $382,703.92 | $397,114.50 | $23,000.00 | $23,000.00 | $23,000.00 | $23,000.00 |
| Cumulative Baseline Cost | $365,747.84 | $748,377.36 | $1,131,081.28 | $1,528,195.78 | $1,551,195.78 | $1,574,195.78 | $1,597,195.78 | $1,620,195.78 |
| **Actual Incurred Costs** | | | | | | | | |
| Federal Share | $326.84 | $17,208.52 | $17,282.92 | $31,693.50 | $31,572.56 | $25,465.07 | $13,078.68 | $52,993.14 |
| Non-Federal Share | $0.00 | $6,475.85 | $43,028.94 | $9,058.04 | $15,226.34 | $0.00 | $0.00 | $0.00 |
| Total Incurred Costs-Quarterly (Federal and Non-Federal) | $326.84 | $17,208.52 | $60,311.86 | $40,751.54 | $46,798.90 | $25,465.07 | $13,078.68 | $52,993.14 |
| Cumulative Incurred Costs | $326.84 | $17,535.36 | $77,847.22 | $118,598.76 | $165,397.66 | $190,862.73 | $203,941.41 | $256,934.55 |
| **Variance** | | | | | | | | |
| Federal Share | $0.00 | $0.00 | $0.00 | $0.00 | -$8,572.56 | -$2,465.07 | $9,921.32 | -$29,993.14 |
| Non-Federal Share | $365,421.00 | $358,945.15 | $322,392.06 | $356,362.96 | -$15,226.34 | $0.00 | $0.00 | $0.00 |
| Total Variance-Quarterly Federal and Non-Federal) | $365,421.00 | $358,945.15 | $322,392.06 | $356,362.96 | -$23,798.90 | -$2,465.07 | $9,921.32 | -$29,993.14 |
| Cumulative Variance | **$365,421.00** | **$724,366.15** | **$1,046,758.21** | **$1,403,121.17** | **$1,379,322.27** | **$1,376,857.20** | **$1,386,778.52** | **$1,356,785.38** |

| | | BP2 Starts 2/1/14 | Ends 9/30/14 | | BP3 Starts 10/1/14 | Ends 9/30/16 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Baseline Reporting Quarter | 10/1/13 - 12/31/13 Q9 | 1/1/14 - 3/31/14 Q10 | 4/1/14 - 6/30/14 Q11 | 7/1/14 - 9/30/14 Q12 | 10/1/14 - 12/31/14 Q13 | 1/1/15 - 3/31/15 Q14 | 4/1/15 - 6/30/15 Q15 | 7/1/15 - 9/30/15 Q16 | 10/1/15 - 12/31/15 Q17 | 1/1/16 - 3/31/16 Q18 | 4/1/16 - 6/30/16 Q19 | 7/1/16 - 9/30/16 Q20 |
| Federal Share | $1,997,070.75 | $1,997,070.75 | $1,997,070.75 | $1,997,070.75 | $325,087.75 | $325,087.75 | $325,087.75 | $325,087.75 | $325,087.75 | $325,087.75 | $325,087.75 | $325,087.75 |
| Non-Federal Share | $258,982.75 | $258,982.75 | $258,982.75 | $258,982.75 | $184,656.00 | $184,656.00 | $184,656.00 | $184,656.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| Total Planned (Federal and Non-Federal) | $2,256,053.50 | $2,256,053.50 | $2,256,053.50 | $2,256,053.50 | $509,743.75 | $509,743.75 | $509,743.75 | $509,743.75 | $325,087.75 | $325,087.75 | $325,087.75 | $325,087.75 |
| Cumulative Baseline Cost | $3,876,249.28 | $6,132,302.78 | $8,388,356.28 | $10,644,409.78 | $11,154,153.53 | $11,663,897.28 | $12,173,641.03 | $12,683,384.78 | $13,008,472.53 | $13,333,560.28 | $13,658,648.03 | $13,983,735.78 |
| Federal Share | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| Non-Federal Share | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| Total Incurred Costs-Quarterly (Federal and Non-Federal) | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| Cumulative Incurred Costs | $256,934.55 | $256,934.55 | $256,934.55 | $256,934.55 | $256,934.55 | $256,934.55 | $256,934.55 | $256,934.55 | $256,934.55 | $256,934.55 | $256,934.55 | $256,934.55 |