

**US Department of Energy  
National Energy Technology Laboratory (NETL)**

**Project Number DE-FE0024431**

**A Nonconventional CO<sub>2</sub>-EOR Target in the Illinois Basin: Oil Reservoirs of  
the Thick Cypress Sandstone**

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Signature of Submitting Official:

Nathan D. Webb: 

## 2. ACCOMPLISHMENTS

*What was done? What was learned?*

Overall, this project is on schedule and within the budget for this quarter. Major accomplishments this quarter include the following:

- The first all staff meeting to introduce the project was held on November 2, 2014.
- PI Nathan Webb and Co-PI Scott Frailey attended the US Department of Energy (DOE) kickoff meeting on December 4, 2014, in Morgantown, WV.
- The project management plan was completed and delivered electronically to the DOE project manager on December 15, 2014.
- This project was announced at two professional meetings (further detailed under Subtask 2.1) where industry representatives that actively drill wells in the Illinois Basin were present. We openly invited those who might be drilling through the thick Cypress to partner with us for drilling whole core and taking new logs.

*What are the major goals of the project and what was accomplished under these goals?*

The major goals of this project include identifying and quantifying nonconventional CO<sub>2</sub> storage and EOR opportunities in the thick Cypress Sandstone in the Illinois Basin through geologic reservoir characterization, three dimensional geocellular modeling, fluid properties and interaction modeling, and reservoir simulation. A study of the economics of potential storage and EOR programs in the thick Cypress sandstone will be made with considerations for production net carbon negative oil. Field development strategies will be recommended with an emphasis on near term deployment. Accomplishments towards these goals are listed below by task as outlined in the statement of project objectives.

Task 1.0–Project Management and Planning (on schedule)

- Progress on completion of tasks, subtasks, deliverables, and milestones is tracked using Microsoft Project to ensure timely completion. Overall, this project is on schedule.
- The PI and Co-PIs met weekly to discuss project management.
- There have been regular meetings with the PI and subtask leaders for active subtasks.

Task 2.0–Geology and Reservoir Characterization (on schedule)

### *Subtask 2.1–Literature Review and Oilfield Selection*

- A compilation and review of past studies of the Cypress Sandstone is underway. Thus far, examples of past studies include published Illinois State Geological Survey (ISGS) oilfield studies that were funded by the DOE; ISGS mapping and outcrop studies; undergraduate, MS, and PhD theses; abstracts from conference presentations; unpublished manuscripts of studies conducted by past ISGS staff; unpublished engineering reports of oil fields from operators in the Illinois Basin; published reports of studies by other state geological surveys in the Illinois Basin. Data from these past publications is being assembled in a digital database.
- The project PI and Co-PI attended two functions where industry representatives were present to increase operator awareness of the project and to begin establishing connections with potential partners for taking new core and logs. These functions included:
  - An Illinois Geological Society meeting held on November 12, 2014, in Mt. Vernon, IL. At this meeting, the PI gave a short presentation to attendees on the objectives of the project and emphasized the need for a partner operator to help with new core and geophysical log acquisition.
    - This meeting resulted in discussions with a number of operator representatives about past production attempts, areas of the Illinois Basin to investigate, available core for study, and the potential for obtaining new cores and geophysical logs as part of this project. The PI has followed up with interested parties by phone and e-mail since the meeting.
  - A Petroleum Technology Transfer Council workshop held on December 9–11, 2014, in Evansville, IN. A flyer was created and distributed to meeting attendees advertising the project. An announcement about the project was made at the workshop by one of the Co-PIs, Scott Frailey.
    - This meeting resulted in immediate interest from a handful of operators or and consultants who will be drilling through or who are aware of people drilling through the thick Cypress sandstone. We have followed up with each party that expressed interest in helping with the coring and collection of geophysical logs.

- The oilfield selection group, led by John Grube, has been meeting weekly to assess the thick Cypress Sandstone in the ILB and choose candidate study areas. Ideally, the study area would occur at the intersection of three important data types critical to the success of the project, including reservoir data, production history, and active drilling (Figure 1).
  - Eight candidate oil field study areas in the thick Cypress Sandstone fairway are being investigated (Figure 2; Table 1).
  - Type logs (Figure 3), preliminary cross sections, and oil field statistical data (Table 1) are being gathered and prepared in each of the candidate study areas so that the areas can be compared and an appropriate study area for detailed characterization selected.

#### Task 3.0–Geocellular and Reservoir Modeling (on schedule)

##### *Subtask 3.1–Historical Production and Injection Data Analysis*

- The data synthesis and analysis group, led by Nathan Grigsby, met on November 12, 2014, to review the process of finding historical production data, and the group reviewed production data for a few selected areas. The group has since been reviewing available production data for candidate study areas and has discussed the components of a database for the project.

#### Task 4.0–CO<sub>2</sub> EOR and Storage Development Strategies (not yet started)

- Nothing to report. Task begins on 03/01/2015.

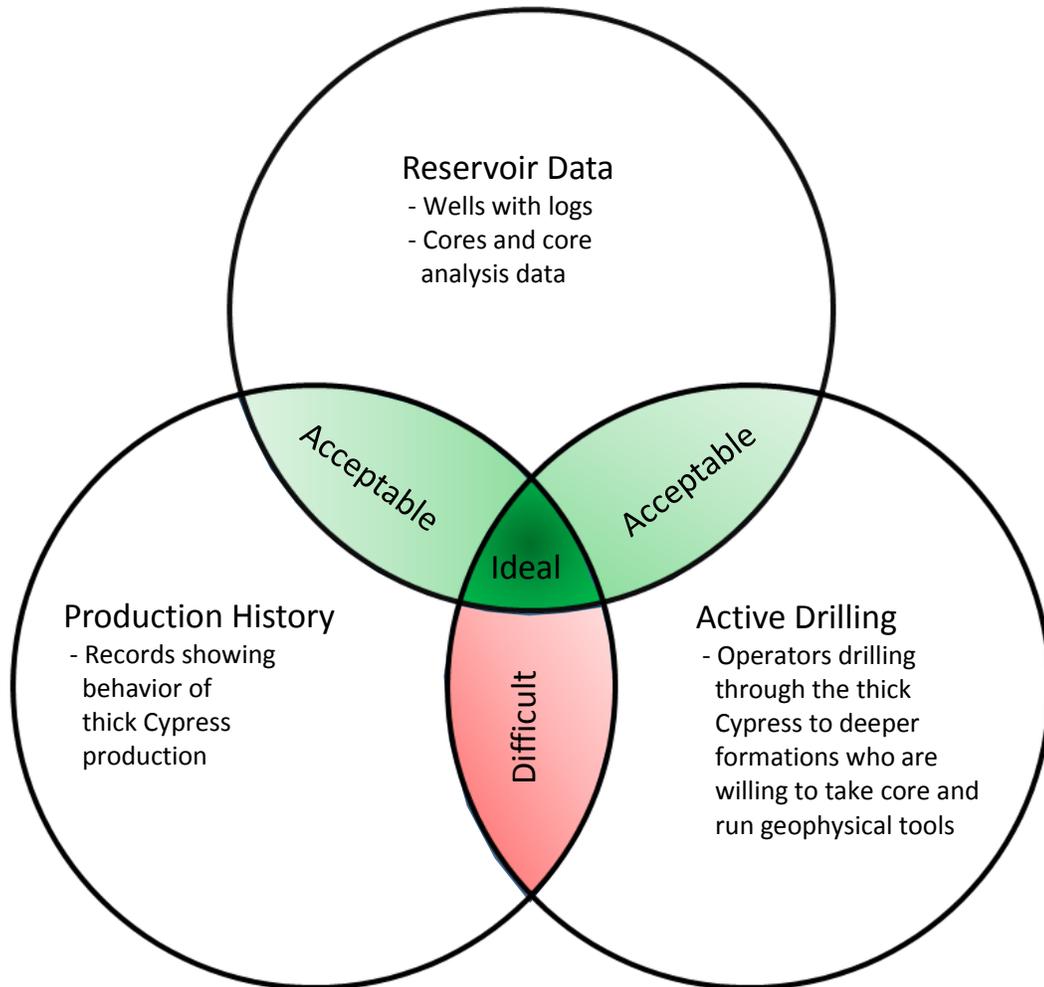


Figure 1. The diagram shows three main data types required for the study. First, the study area should have historical production data that documents past attempts at production from the thick Cypress sandstone in order to establish typical decline curves. Second, the study area should contain abundant wells with geophysical log data, which are prerequisites for cross-section correlation, isopach and structure mapping, and ultimately three-dimensional geocellular modeling to be used in reservoir simulations. Building a detailed conceptual geologic model would be difficult without such geophysical data. Third, the study area should be located in an area of active drilling by current operators. These operators may be drilling to deeper, more reliably productive horizons than the Cypress, but in drilling through the thick Cypress, the operators may be amenable to coring the Cypress interval with funds provided by this project. The core will give a detailed look at reservoir conditions in the study area.

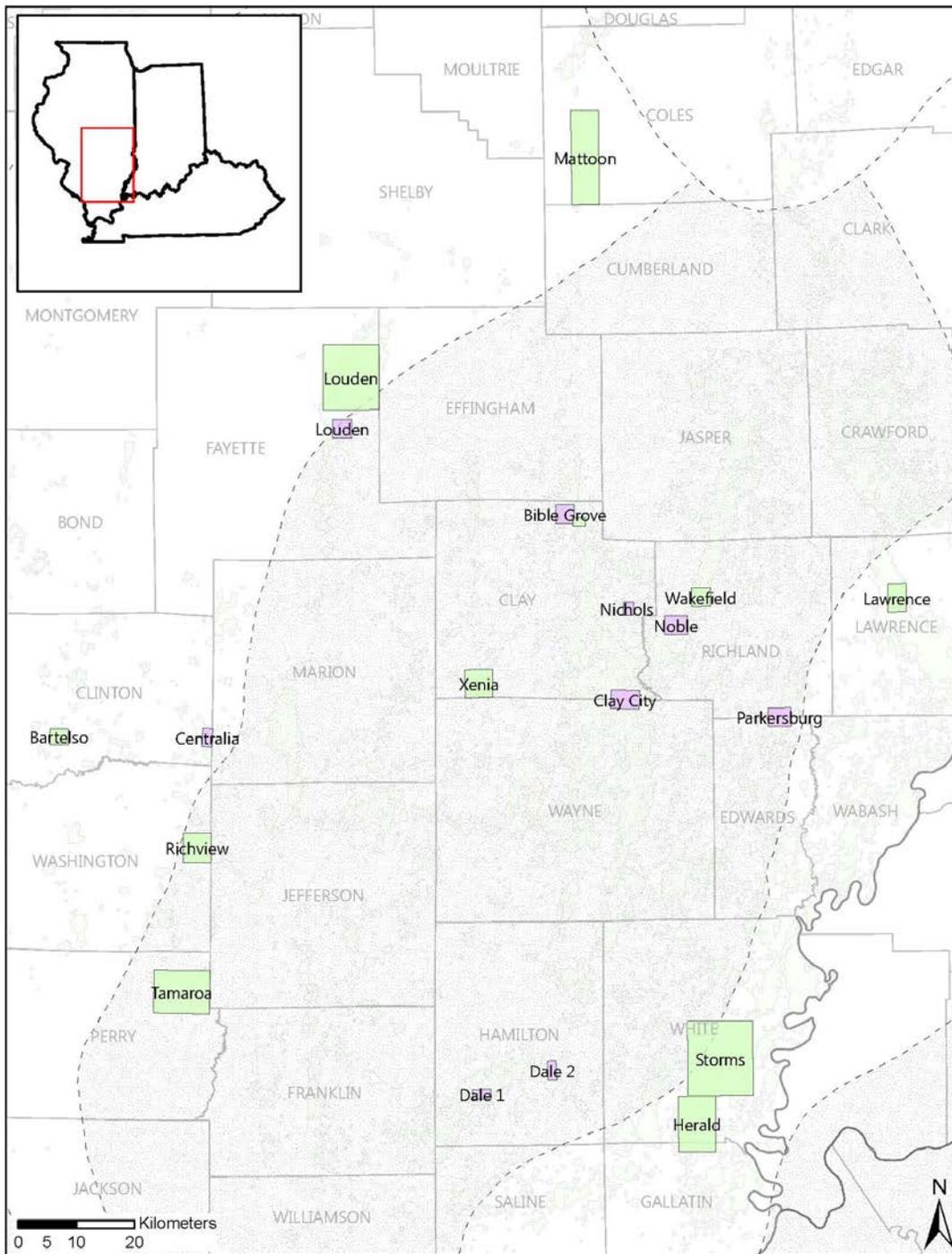


Figure 2. Preliminary map showing eight candidate study areas (in purple; Table 1) within the fairway of the thick Cypress Sandstone (stippled) in Illinois. Each study area is being assessed for available data (Figure 1). Areas where the Cypress Sandstone has been studied in oil fields in the past are shown with green boxes.

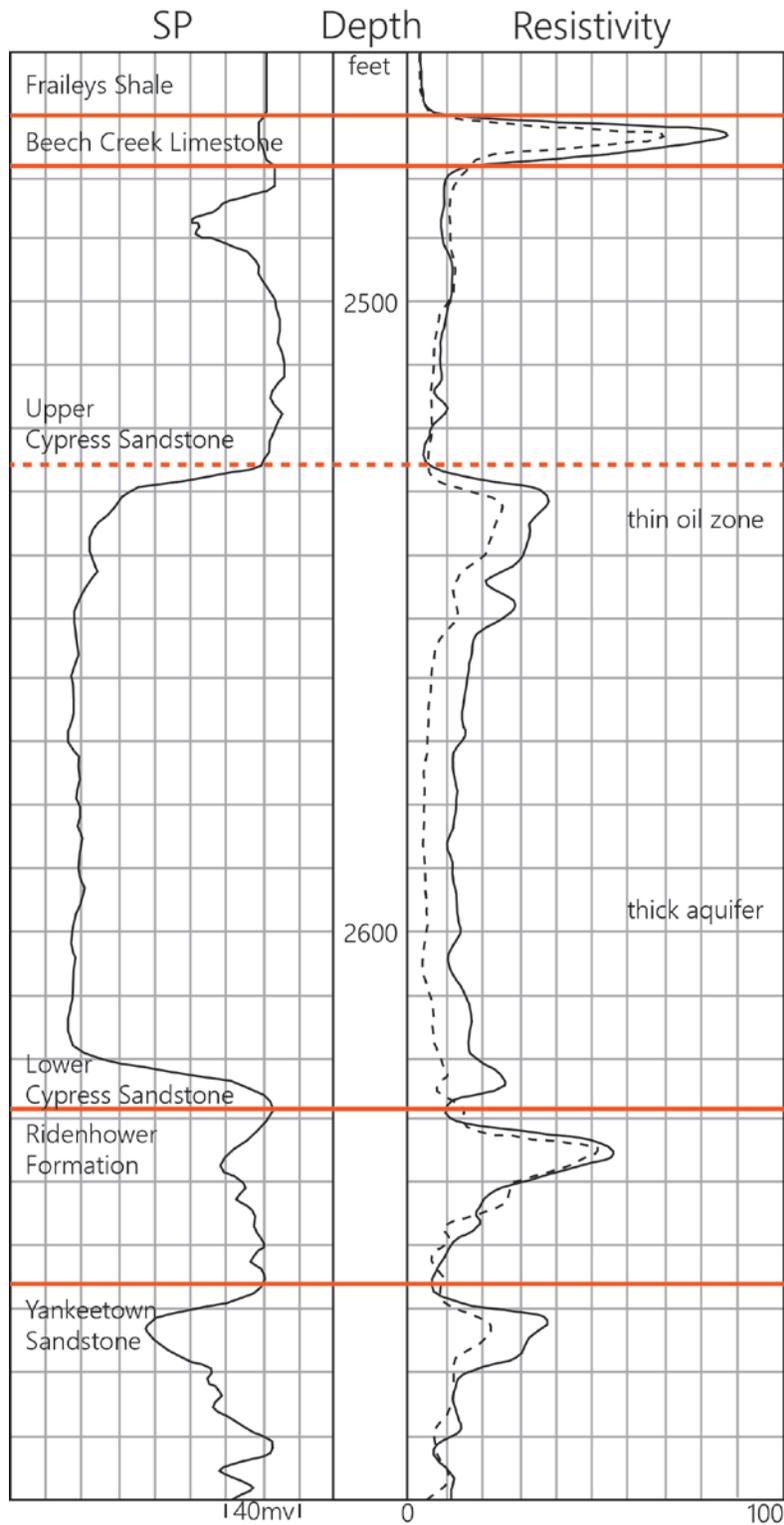


Figure 3. Example type log that shows an electric log signature through the thick Cypress Sandstone interval in the Bible Grove area (Figure 2).

Table 1. Attributes of the thick Cypress Sandstone and data availability in candidate study areas. Depths to and thicknesses of the thick Cypress Sandstone are representative. The thin oil zone is identified by a high resistivity trend and possible suppression of the spontaneous potential curve on the electric log as well as records of oil production or oil shows. In places where the oil zone is indicated, its thickness is approximated from the resistivity curves. Reservoir data includes geophysical log data, cores, and core analysis (porosity and permeability) data. Production history includes reports of monthly and cumulative oil production, usually grouped by lease. Active drilling indicates that drilling permits were issued within the candidate study area location in calendar year 2014.

<b>Oilfield Name</b>	<b>Location</b>	<b>Average Depth to Cypress</b>	<b>Average Cypress Thickness</b>	<b>Thin oil zone present?*</b>	<b>Reservoir Data</b>	<b>Production History*</b>	<b>Active Drilling (2014)</b>
Loudon	Fayette Co., T7N, R3E	1500'	70'	Yes >10'	Many electric logs and porosity logs, several cores, some core analysis data	Yes	Yes
Bible Grove	Clay Co., T5N, R7E	2500'	100'	Yes >10'	Many electric logs, a few cores nearby, little core analysis data	Yes	No
Nichols	Clay Co., T4N, R8E	2700'	150'	Yes >10'	Many electric logs, no cores, little core analysis data	Yes	Yes
Noble	Richland Co., T3N, R9E	2600'	150'	Yes >10'	Many electric logs and porosity logs, a few cores, abundant core analysis data	Yes	Yes
Clay City	Clay and Wayne Co., T2N, R8E	2700'	90'	Yes <10'	Many electric logs and porosity logs, no cores, some core analysis data	Yes	No
Parkersburg	Richland/Edwards Co., T2N, R14W	2800'	Transitioning to thinner stacked sandstones	Not yet determined	Many electric logs and porosity logs, no cores, some core analysis data	Not yet determined	Yes
Centralia	Clinton Co., T1N, R1W	1200'	Transitioning to thinner stacked sandstones	Not yet determined	Many old electric logs with many that do not penetrate the entire Cypress, a few cores, some core analysis data	Not yet determined	No
Dale 1 & 2	Hamilton Co., T6S, R5E & T6S R7E	2700-2900'	70-90'	Yes <10'	Many electric logs, A few cores, no core analysis data	No	No

\*An entry of "Not yet determined" indicates that the oil zone may be very thin, if present, and is difficult to detect due to the transitional nature of the Cypress Sandstone in the Centralia and Parkersburg areas. Additional examination of production records and advanced well log analyses are needed to make final determinations.

*What opportunities for training and professional development has the project provided?*

Nothing to report.

*How have the results been disseminated to communities of interest?*

The project PI and Co-PI attended two functions (detailed under Accomplishments) where industry representatives were present to increase operator awareness of the project and to begin establishing connections with potential partners for taking new core and geophysical logs.

*What do you plan to do during the next reporting period to accomplish the goals of the project?*

Task 1.0–Project Management and Planning (on schedule)

- Progress on completion of tasks, subtasks, deliverables, and milestones will continue to be tracked using Microsoft Project to ensure timely completion.
- The PI and Co-PIs will continue to meet weekly to discuss project management.
- Regular meetings with the PI and subtask leaders will continue for active subtasks.

Task 2.0–Geology and Reservoir Characterization (on schedule)

*Subtask 2.1–Literature Review and Oilfield Selection*

- The literature review will continue and oil field selection will be complete by 3/31/2015.

*Subtask 2.2–Petrophysical Analysis*

- A preliminary meeting to assess available data will be held.
- Areas within the thick Cypress fairway with complete well log suites (resistivity and porosity) will be identified.
- Routine log analyses will be conducted
- Preliminary oil saturation calculations and inferences of the presence of residual oil zone and/or capillary transition zones will be made.

*Subtask 2.3–Geologic Model Development*

- Cursory geologic studies (including choosing a type log, constructing representative cross sections, and reviewing available core data) will be conducted in candidate study areas.
- Geologic model will begin to be constructed from preliminary cross sections.
- A database of available core will be assembled and preliminary core descriptions will begin.

Task 3.0–Geocellular and Reservoir Modeling (on schedule)

*Subtask 3.1–Historical Production and Injection Data Analysis*

- Production history data will begin to be compiled into a database that can be used for decline curve analysis.
- Log digitizing will begin.

*Subtask 3.2–Illinois Basin Crude Oil/brine-CO<sub>2</sub> Fluid Property Characterization*

- Subtask begins on 3/1/2015.
- Preliminary preparations for fluid sampling will begin.

*Subtask 3.3–Geocellular Modeling of Interwell Reservoir Characteristics*

- Subtask begins on 3/1/2015.
- Preliminary discussions of model parameters, resolution, algorithms will take place.

*Subtask 3.4–Reservoir Modeling*

- Subtask begins on 6/1/2015.

Task 4.0–CO<sub>2</sub> EOR and Storage Development Strategies (not yet started)

*Subtask 4.1–Field Development Strategies*

- Subtask begins on 4/1/2016.

*Subtask 4.2–CO<sub>2</sub> EOR and Storage Resource Assessment*

- Subtask begins on 11/1/2015.

*Subtask 4.3–Economic Analysis*

- Subtask begins on 4/1/2016.

### Project Milestone Log

Task	Calendar Year	Milestone Title/Description	Planned Completion Date	Actual Completion Date	Verification Method	Comments
1.0	1	Project Management Plan	12/31/2014	12/15/2014	PMP File	Completed
1.0	1	Kickoff Meeting	12/31/2014	12/4/2014	Presentation File	Completed
2.0	2	Final selection of oilfields for study	3/31/2015		Agreement between ISGS and DOE project manager to proceed with specific areas of study	20% Complete
2.0	2	Oilfield data synthesis and analysis	10/31/2015		Wells/leases grouped into classes representing relative degree of productivity	5% Complete
2.0, 3.0	3	Complete petrophysical analysis, geologic and geocellular modeling of the thick Cypress	10/31/2016		Completion of draft topical report on geology of the thick Cypress in the ILB	0% Complete
4.0	3	Complete guidelines to develop thin oil zones and store CO <sub>2</sub> in the thick Cypress	12/31/2016		Completion of draft topical report on guidelines to develop thin oil zones in the thick Cypress	0% Complete
4.0	4	Complete estimates of CO <sub>2</sub> -EOR and storage potential and economic analysis of implementing program	8/30/2017		Completion of draft topical report on CO <sub>2</sub> -EOR, storage, and economics of the thick Cypress in the ILB	0% Complete
All	4	Document project results	10/31/2017		Complete final report	In progress

### **3. PRODUCTS**

*What has the project produced?*

A presentation titled “A Nonconventional CO<sub>2</sub>-EOR Target in the Illinois Basin: Oil Reservoirs of the Thick Cypress Sandstone” was given by the PI at the DOE kickoff meeting for successful applicants under DE-FOA-0001110 at the National Energy Technology Laboratory facility in Morgantown, WV, on December 4, 2014.

### **4. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS**

Nothing to report.

### **5. IMPACT**

Nothing to report.

### **6. CHANGES/PROBLEMS**

*Changes in approach and reasons for change*

There have been no changes in approach on this project.

*Actual or anticipated problems or delays and actions or plans to resolve them*

There are currently no anticipated problems or delays in the project.

*Changes that have a significant impact on expenditures*

As no changes have been made or are anticipated, none are expected to impact expenditures.

*Significant changes in use or care of human subjects, vertebrate animals, and/or Biohazards*

Not applicable.

*Change of primary performance site location from that originally proposed*  
Not applicable.

## **7. Special Reporting Requirements**

Nothing to report.

## 8. Budgetary Information

### Financial Reporting Table

Baseline Reporting	Budget Period 1									Budget Period 2					Total
	11/01/14 - 10/31/16									11/01/16 - 10/31/17					
	FY15 Q1	FY15 Q2	FY15 Q3	FY15 Q4	FY16 Q1	FY16 Q2	FY16 Q3	FY16 Q4	FY17 Q1	FY17 Q1	FY17 Q2	FY17 Q3	FY17 Q4	FY18 Q1	
Baseline Federal Share	192,267.00	192,267.00	192,265.00	193,061.00	177,323.00	177,322.00	177,323.00	177,322.00	58,543.00	117,085.00	175,628.00	175,629.00	117,085.00	58,543.00	2,181,663.00
Baseline non-Federal Share	30,889.33	46,334.00	46,334.00	46,334.00	46,334.00	46,334.00	46,334.00	46,334.00	15,444.67	30,889.00	46,334.00	46,334.00	46,334.00	15,444.00	556,007.00
Total Baseline Cumulative Cost	223,156.33	238,601.00	238,599.00	239,395.00	223,657.00	223,656.00	223,657.00	223,656.00	73,987.67	147,974.00	221,962.00	221,963.00	163,419.00	73,987.00	2,737,670.00
Actual Federal Share	9,661.16														9,661.16
Actual non-Federal Share	29,328.11														29,328.11
Total Actual Cumulative Cost	38,989.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38,989.27
Variance Federal Share	182,605.84	192,267.00	192,265.00	193,061.00	177,323.00	177,322.00	177,323.00	177,322.00	58,543.00	117,085.00	175,628.00	175,629.00	117,085.00	58,543.00	2,172,001.84
Variance non-Federal Share	1,561.22	46,334.00	46,334.00	46,334.00	46,334.00	46,334.00	46,334.00	46,334.00	15,444.67	30,889.00	46,334.00	46,334.00	46,334.00	15,444.00	526,678.89
Total Variance Cumulative Cost	184,167.06	238,601.00	238,599.00	239,395.00	223,657.00	223,656.00	223,657.00	223,656.00	73,987.67	147,974.00	221,962.00	221,963.00	163,419.00	73,987.00	2,698,680.73