Field Demonstration of CO_2 Miscible Flooding in the Lansing-Kansas City Formation, Central Kansas

Class II Revisited DE-AC26-00BC15124

November 1, 2008

Tertiary Oil Recovery Advisory Board Meeting

Lawrence, Kansas

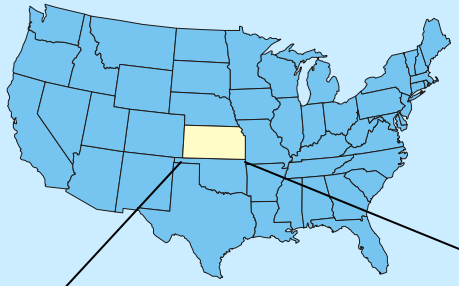
University of Kansas

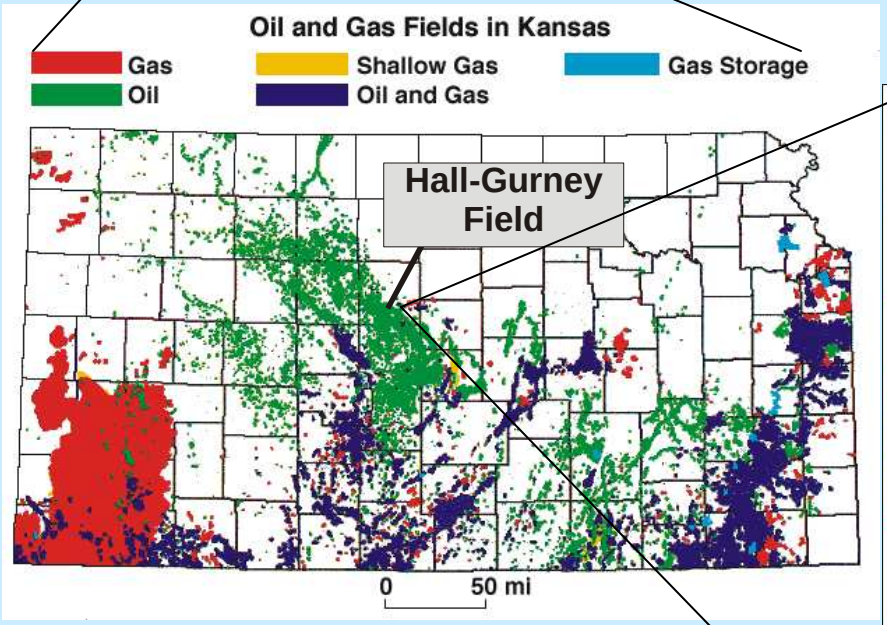
G. Paul Willhite, Tertiary Oil Recovery Project

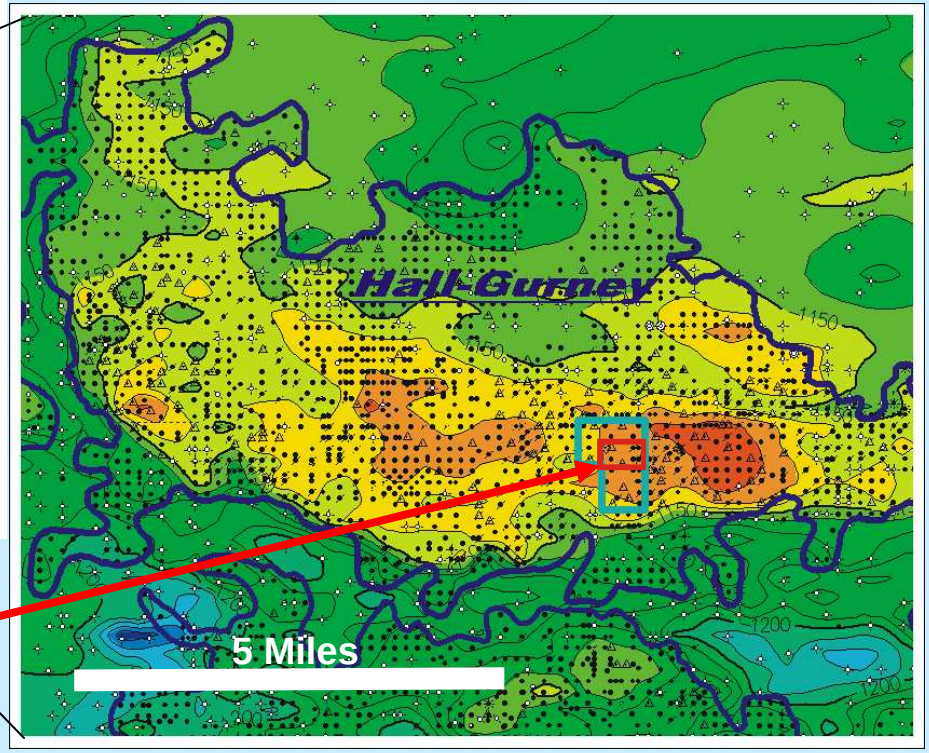
Overview

- Demonstration Site
- Objectives
- Working Interest Partners
- Field Demonstration Plan
- Milestones
- Oil Production Response
- Management Plan
- Evaluation of Potential for Commercial Operation

Lansing-Kansas City Production and Project Location







CO2 Pilot Study Area

Partners

MURFIN DRILLING COMPANY, INC.
WICHITA, KANSAS

JOHN O. FARMER, INC.

White Eagle Resources

United States Department of Energy
Science, Security and Energy: Powering the 21st Century

KANSAS DEPARTMENT of COMMERCE

KTEC KANSAS TECHNOLOGY ENTERPRISE CORPORATION

KU University of Kansas

KANSAS GEOLOGICAL SURVEY

T.O.R.P.

KINDER MORGAN

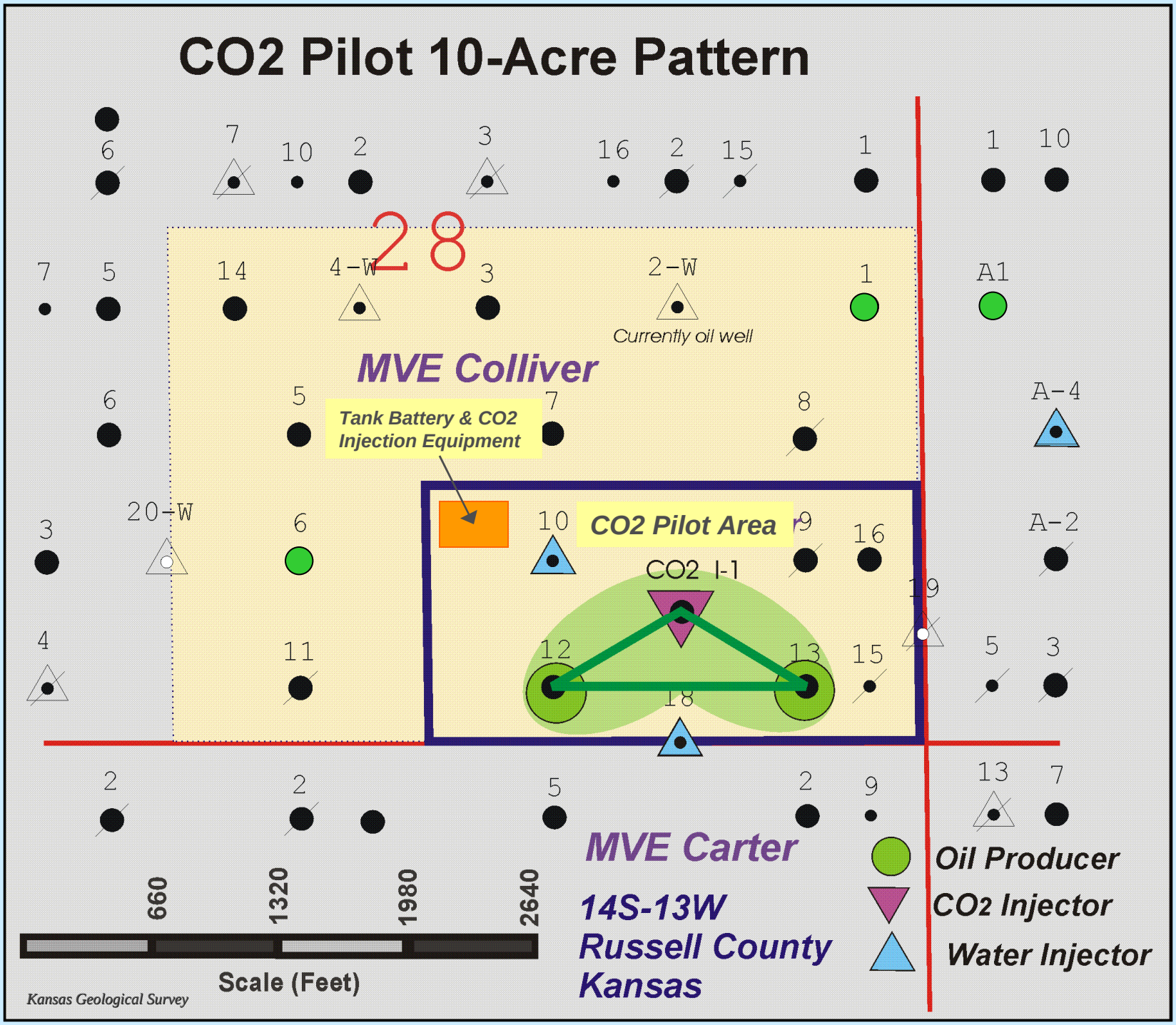
U.S. ENERGY PARTNERS, L.L.C.

TRILOBITE TESTING, INC.

EPCO
CARBON DIOXIDE PRODUCTS INCORPORATED

Purpose of Demonstration

- Determine the technical and economic feasibility of using CO_2 miscible flooding to recover residual and bypassed oil in LKC shallow shelf carbonates.
- Develop reservoir data for the LKC and Hall-Gurney for other floods
- Develop an understanding of operating costs and operating experience for CO_2 miscible flooding in Lansing-Kansas City reservoirs
- **<u>Oil in tank</u> and provide sufficient information to expand to commercial scale**

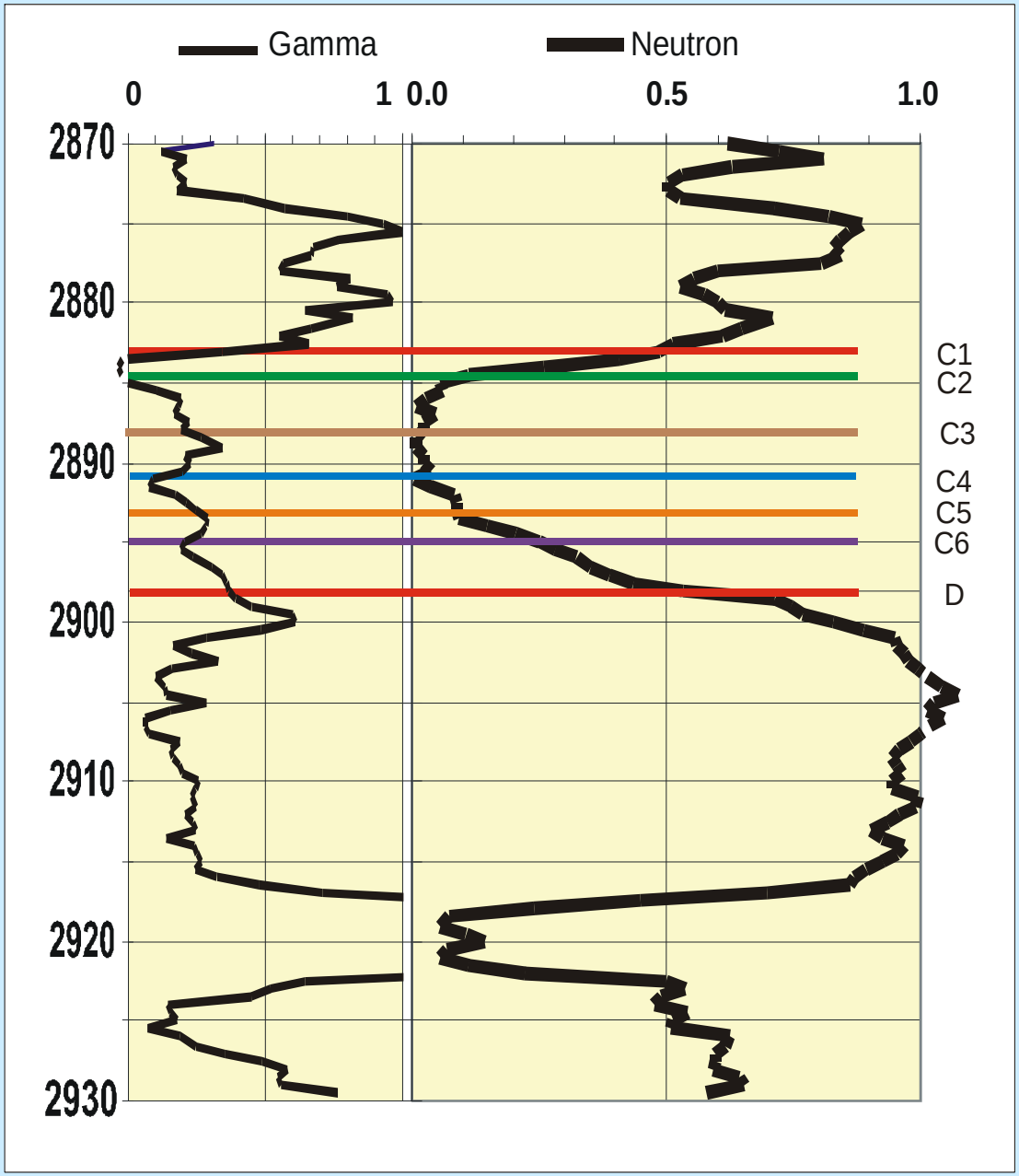

CO2 Pilot 10-Acre Pattern
28
4-W
2-W
Currently oil well
MVE Colliver
Tank Battery & CO2 Injection Equipment
CO2 Pilot Area
CO2 I-1
20-W
A1
A-4
A-2
MVE Carter
14S-13W
Russell County
Kansas
Oil Producer
CO2 Injector
Water Injector
660
1320
1980
2640
Scale (Feet)
Kansas Geological Survey

Type Log CO2#18

L-KC “C” divided into 6 Layers-three flooding cycles

- General Properties*
  - C1: 8 md, 18.8%
  - C2: 150 md, 25.8%
  - C3: 40 md, 22.0%
  - C4: 6 md, 19.4%
  - C5: 2 md, 14.7%
  - C6: 0.3 md, 12.0%

- *- CO2#18 exhibits better properties than average for site



DOE Participation

- Phase One – ***DOE Contribution 45%***
  - March 2000 to January 2004
  - Perform Reservoir Characterization and Simulation
  - Conduct Field Studies to Determine if CO2 Pilot Implementation Feasible (Included Well Workovers and Water Injection Facilities)
  - Develop Working Interest Partnerships and Other Working Agreements (CO2 Supply, CO2 Transport, and CO2 Injection)
  - Pre-startup Activities (Tank Battery Upgrade and CO2 Injection Equipment Set-up)
  - Trial CO2 Injection

DOE Participation

- Phase Two – ***DOE Contribution 35%***
  - February 2004 to December 2008
  - Implement, Operate, and Monitor CO2 Pilot
- Phase Three – ***DOE Contribution 10%***
  - January 2009 to March 2010
  - Post CO2 Flood Monitoring (Water Injection)
  - Continue Tech Transfer Activities

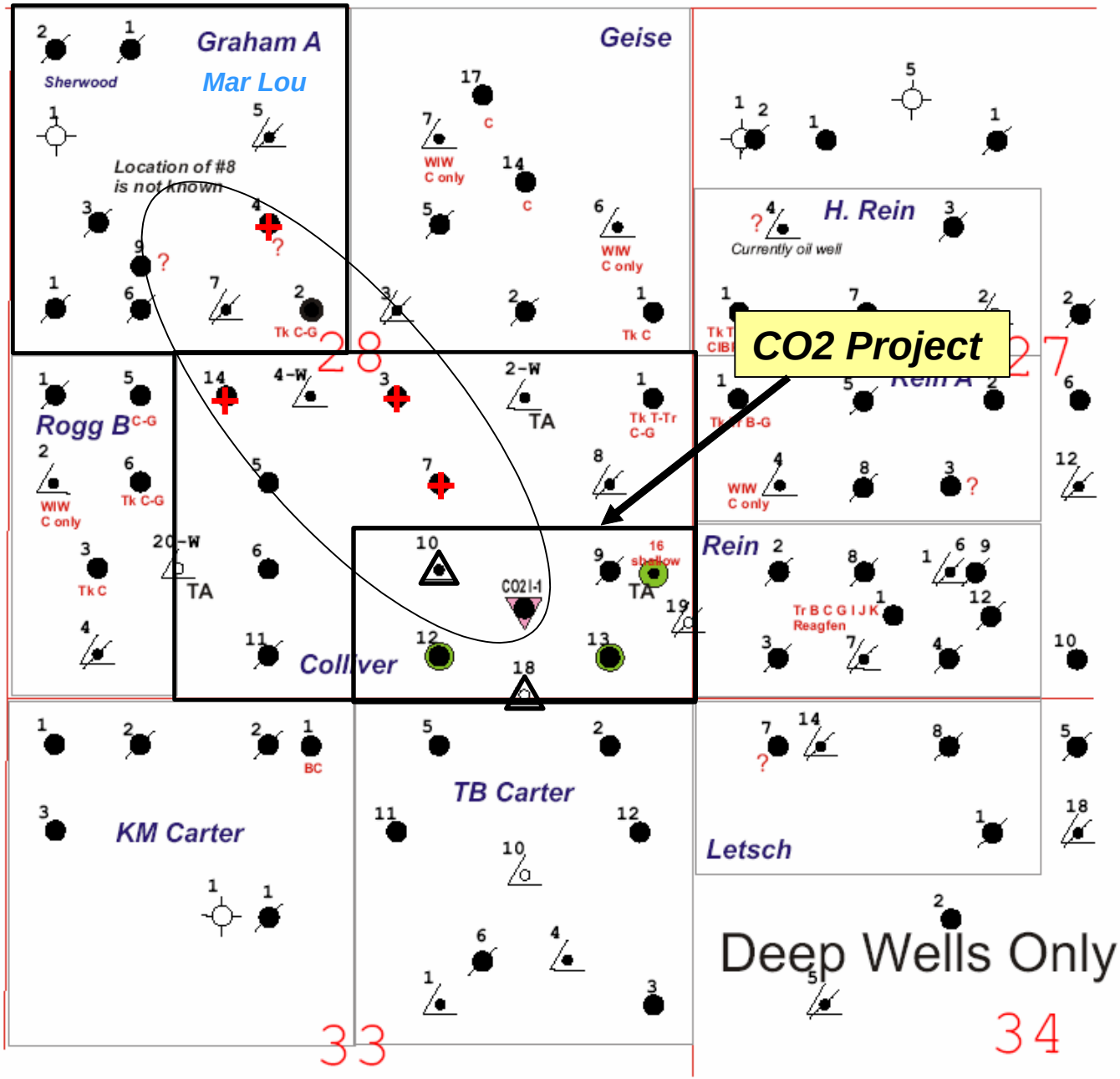
Milestones

- **December 3, 2003-Begin CO2 Injection**
- **February 2004-Initial oil production response in pilot wells~3 B/D**
- **June 2005-Switch to water injection after injection of 16.19 MM lb(138.05 MMCF) of CO2**
- **May 2006- Oil production from pilot increased to 5.5-6 B/D**
- **August 2006-Discovered Increased production from Mar-Lou Lease (NW of Pilot Lease) during April-May 2006-**
- **August 2006-Colliver A7 opened in C zone-substantial increase in oil production on Colliver A Lease**

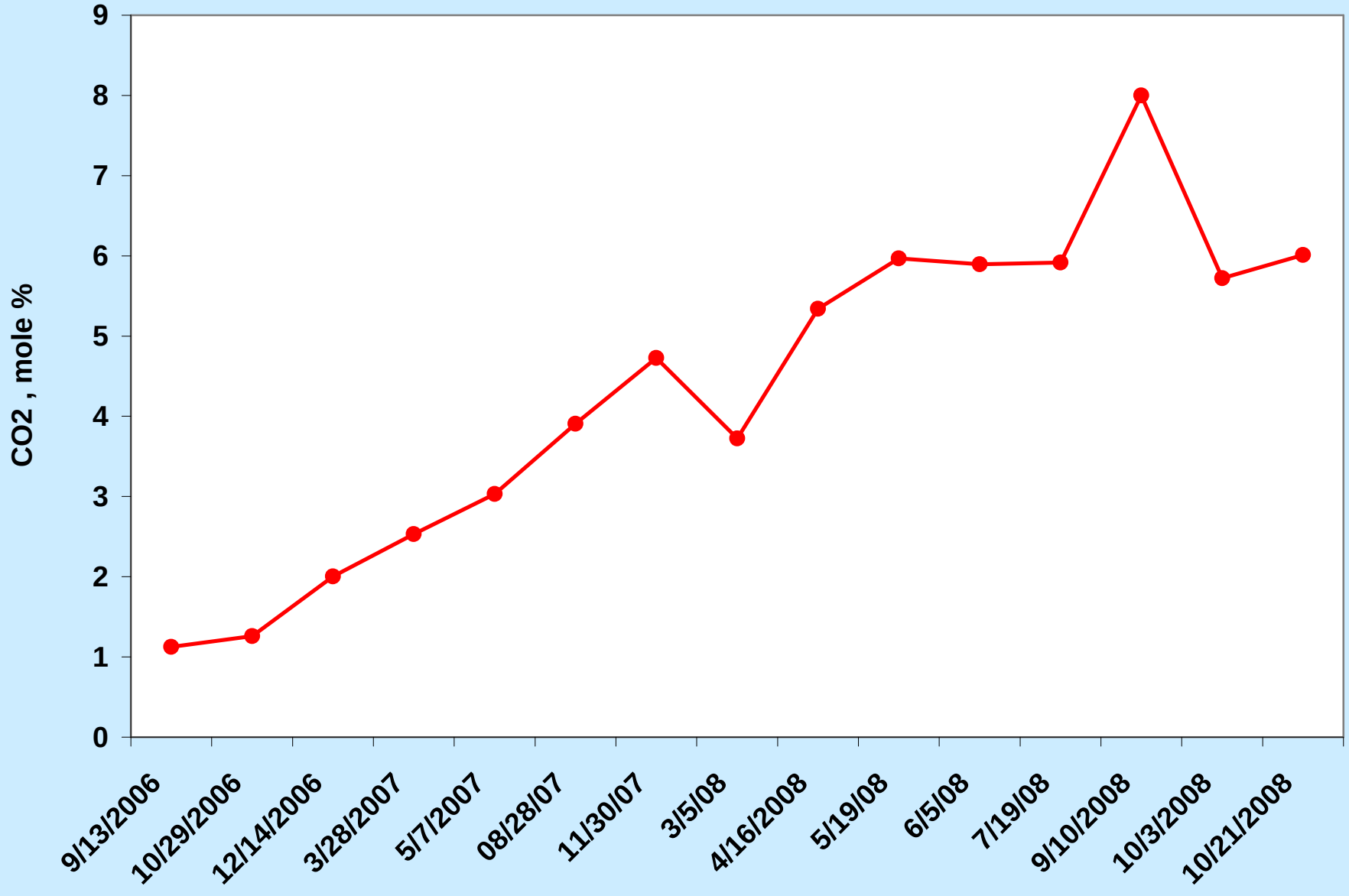
Production from Surrounding Leases

Graham A April-May 2006

Colliver A August 2006



Carbon Dioxide in Produced Gas-Colliver A7



Colliver Lease Production

- **The increased carbon dioxide concentration in the casing gas in Colliver A7 indicates that oil displaced from the CO2 pilot is being produced from Colliver A7**
- **Colliver A14 is also producing incremental oil following recompletion in the C zone. Carbon dioxide content of the casing gas is normal for the area.**

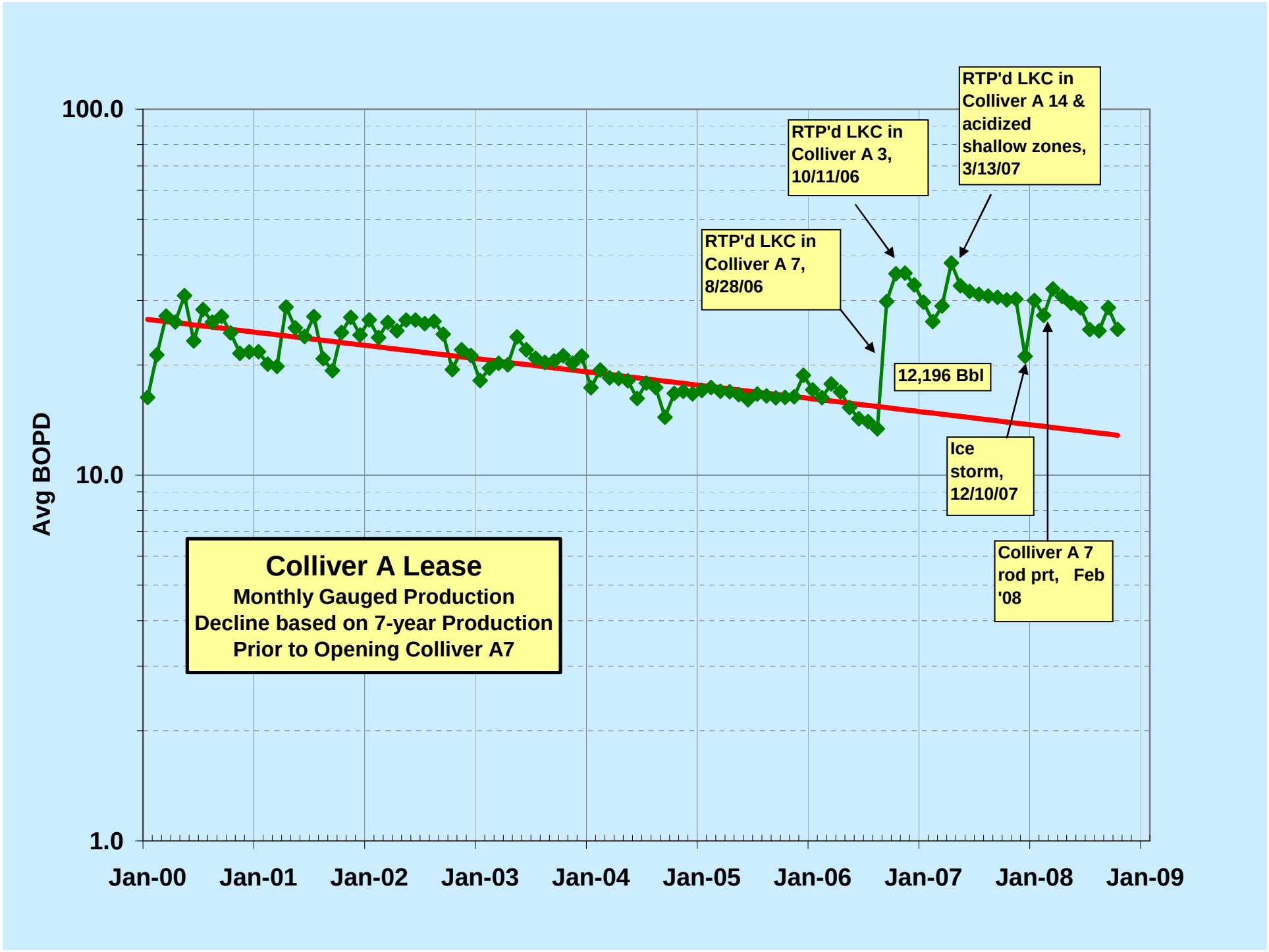

100.0
10.0
1.0
Avg BOPD
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
RTP'd LKC in Colliver A 14 & acidized shallow zones, 3/13/07
RTP'd LKC in Colliver A 3, 10/11/06
RTP'd LKC in Colliver A 7, 8/28/06
12,196 Bbl
Ice storm, 12/10/07
Colliver A 7 rod prt, Feb '08
Colliver A Lease
Monthly Gauged Production
Decline based on 7-year Production
Prior to Opening Colliver A7

Table 1: Estimated Incremental Oil from CO2 Injection into LKC *C*

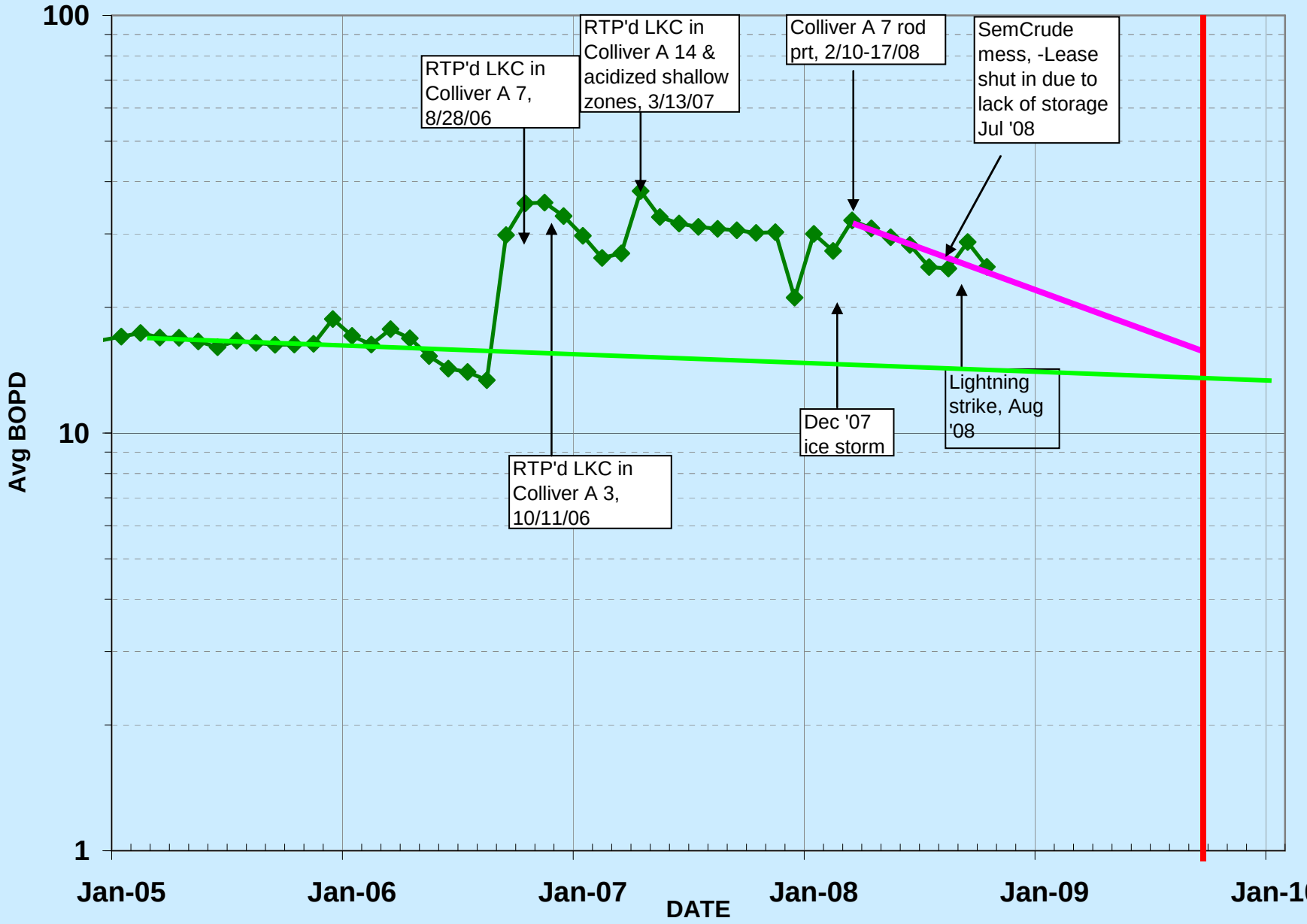
CO2 Injected-138.05 MMCF

Date	CO2 Pilot BBL	Colliver A Lease BBL	Graham A Lease BBL	Total BBL	MCF /BBL
9/30/08	6,836	12,196	920	19,952	6.92

Colliver A Lease

Monthly Gauged Production

10-year Production



Project Management
Budget Period II

- **Project is not economic even with DOE cost share**
- **95% of the CO2 remains in the LKC *C* zone reservoir interval**
- **Maintain pressure in pilot area above MMP(1250 psi)**
- **Inject water into CO2I-1 to continue mobilization of oil by displacing the carbon dioxide**
- **Document oil production from Colliver A Lease that can be attributed to CO2 displacement(no economic benefit to some of the WI owners)**
- **Produce defendable estimates of oil recovery based on *oil in the tank***

DOE Participation

- **Phase Two –** ***DOE Contribution 35%***
  - **February 2004 to December 2008**
  - **Implement, Operate, and Monitor CO2 Pilot**
  - **Continuation application to be prepared to extend some Budget Period 2 activities to June 30, 2009**
- **Phase Three –** ***DOE Contribution 10%***
  - **January 2009 to March 2010**
  - **Post CO2 Flood Monitoring (Water Injection)**
  - **Continue Tech Transfer Activities**

Summary

- **Oil displaced by CO2 injection is being produced from offset leases-primarily Colliver A**
- **Carbon dioxide concentration in Colliver A7 may have peaked**
- **Oil production from CO2 pilot lease appears to be stable(3.5-5 B/D-avg~4.5 B/D)**
- **Estimated incremental oil recovery attributed to CO2 injection from all leases is 6.92 MCF/BBL as of 9/30/08**
- **Reservoir heterogeneity exceeds initial estimates. Current reservoir model does not represent reservoir heterogeneity correctly**
- **10 acre pilot was too small to develop a commercial project**

Project Management
Budget Period II-2008

- **Operate project until effective displacement ends in pilot and adjacent leases.**
- **Revise reservoir description to improve capability of reservoir model to match and predict production**
- **Consider the possibility of expanding the project to commercial scale**

Additional Information

Accessible by from web

- **http://www.torp.ku.edu/**
- **http://www.kgs.ku.edu/CO2/index.html**

Website includes data, reports and PPT presentations