Preliminary Evaluation of Carbon Dioxide-Enhanced Oil Recovery (CO_2-EOR) In Kansas Oilfields

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Abstract

The successful use of carbon dioxide as a tertiary recovery mechanism has grown rapidly in the oil industry to combat global warming. Many mature oilfields in Kansas are currently in the late stage of water injection, making them good candidates for CO_2-EOR. However, several assessments need to be carried out to determine their suitability for this technology. The Kansas Geological Survey (KGS) online database contains a compilation of geologic and engineering resources required for the evaluation of oilfields in Kansas. This database contains well data, secondary recovery and pressure maintenance records, which is the foundation for majority of this work. This study provides a preliminary assessment and identification of oilfields in Kansas with the potential for CO_2-EOR, applying cutoff parameters such as reservoir depth, oil gravity, cumulative oil production and CO_2 miscibility. From an initial selection of 505 fields, 107 oilfields are good candidates for CO_2-EOR. 24 fields are grouped under Tier 1 because they are suitable for miscible CO_2-EOR. 48 fields are classified as Tier 2 (i.e. reservoirs pressures slightly less than estimated MMP) and 34 fields are classified as Tier 3 (i.e. immiscible CO_2-EOR candidates). All selected fields are ranked based on production data to lay the groundwork for further screening and limitations.

Objective

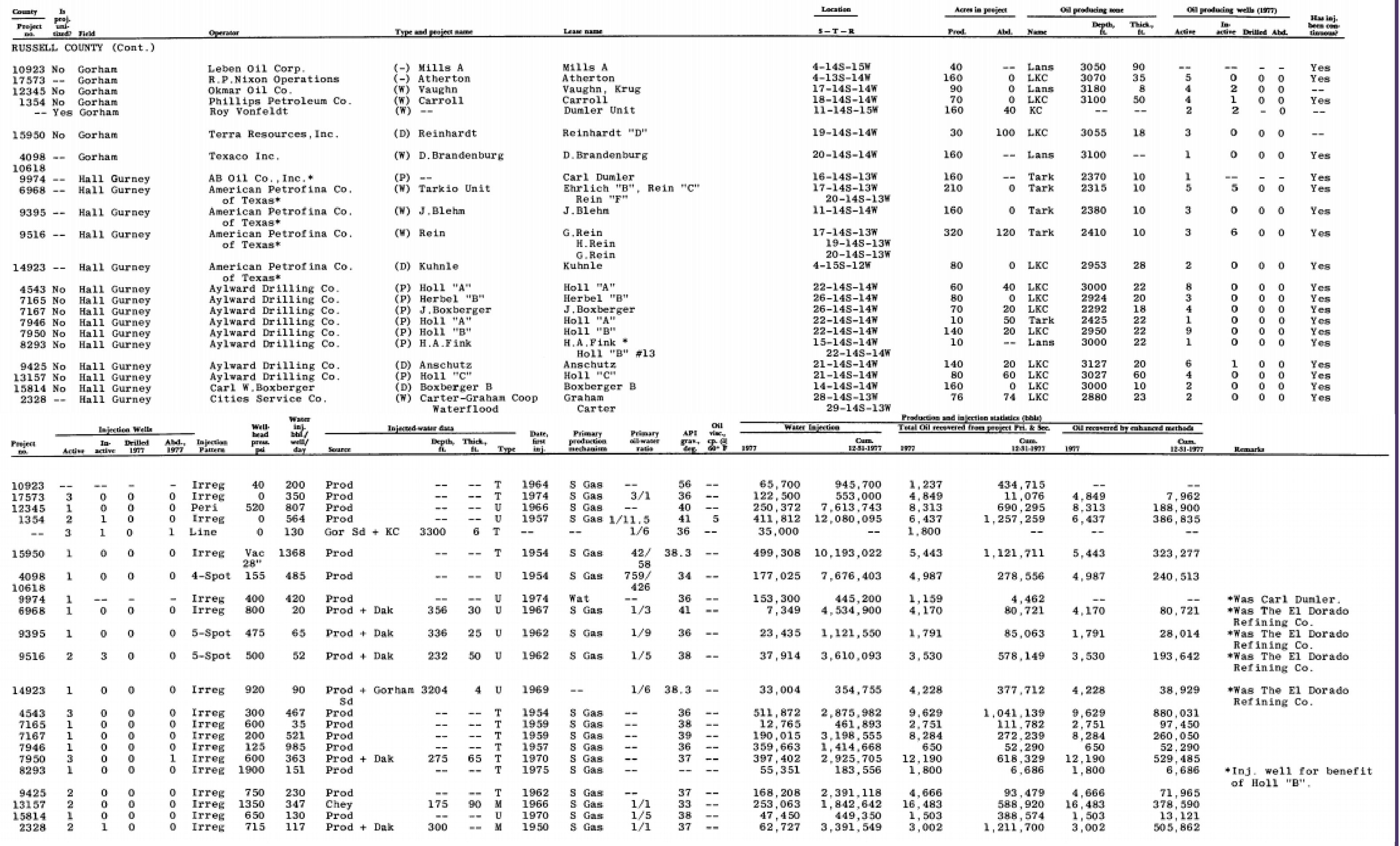
- Identify fields with the potential of CO_2 utilization using specific screening criteria.
- Perform geochemical analysis for selected potential fields.

Database

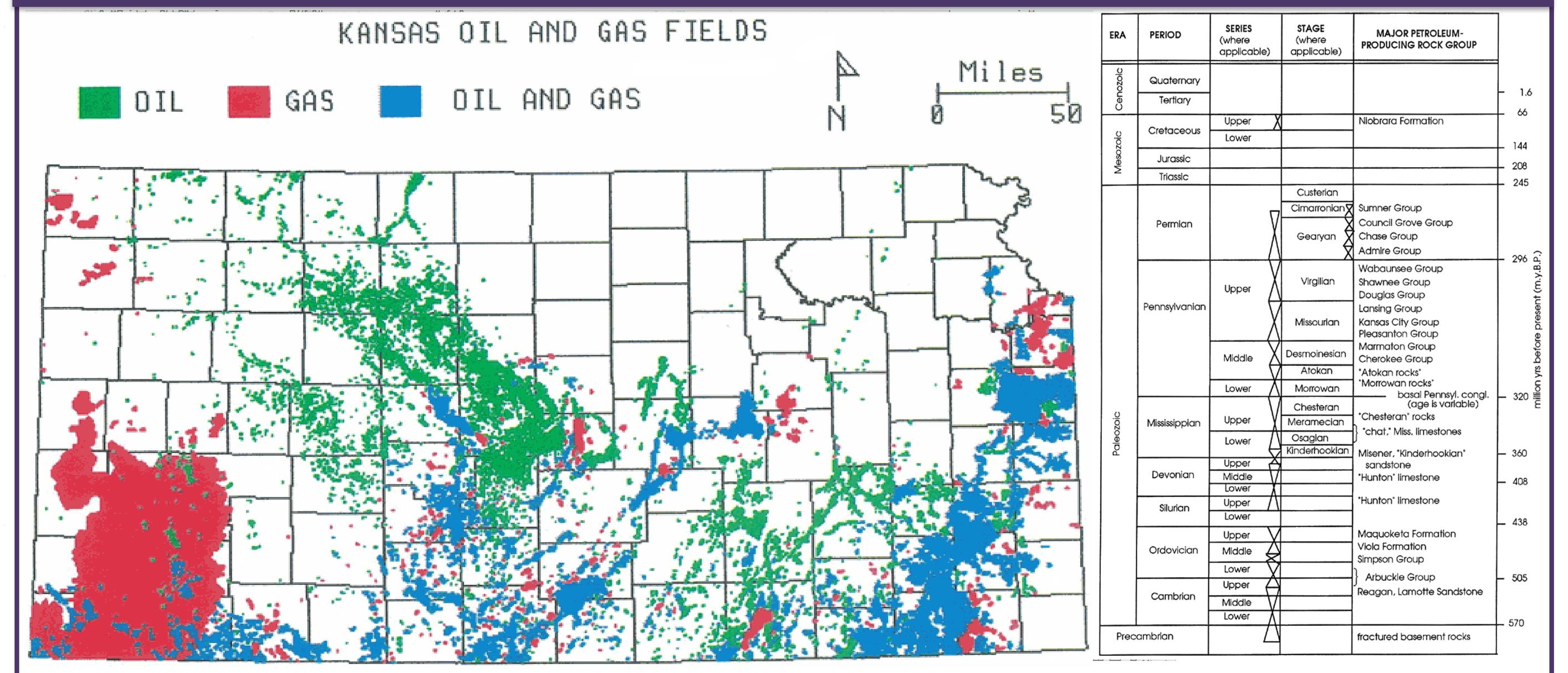
- **Kansas Geological Survey**
  - Waterflood Records between 1964 to 1981

  Reason: (1) Advanced stage of waterflood or aquifer encroachment.

  (2) No prior tertiary oil recovery that can cause complex miscibility with CO_2.
  - Approx. 2,800 fields.
  - Lithology of production/injection zones
  - Field depth, oil gravity (API) & viscosity
  - Production and water injection volumes
  - Drill Stem Test (DST) & Well logs
- Min. condition for supercritical CO_2:
  - 87.8°F (31.04°C) and 1071psia (7.39MPa)
  - Assume pressure gradient of 0.433 psia/ft
  - Min. depth able to retain CO_2 = 2,473 ft
- In Kansas, production depth ranged from 1,700 – 6,200ft
- Oil gravity ranged from 20 to 60°API (indicating slightly heavy to extra-light crude or condensates).
- A min. depth of 2,400 ft was chosen to include as many fields as possible.
- Minimum oil gravity of 22° API



Screening Criteria

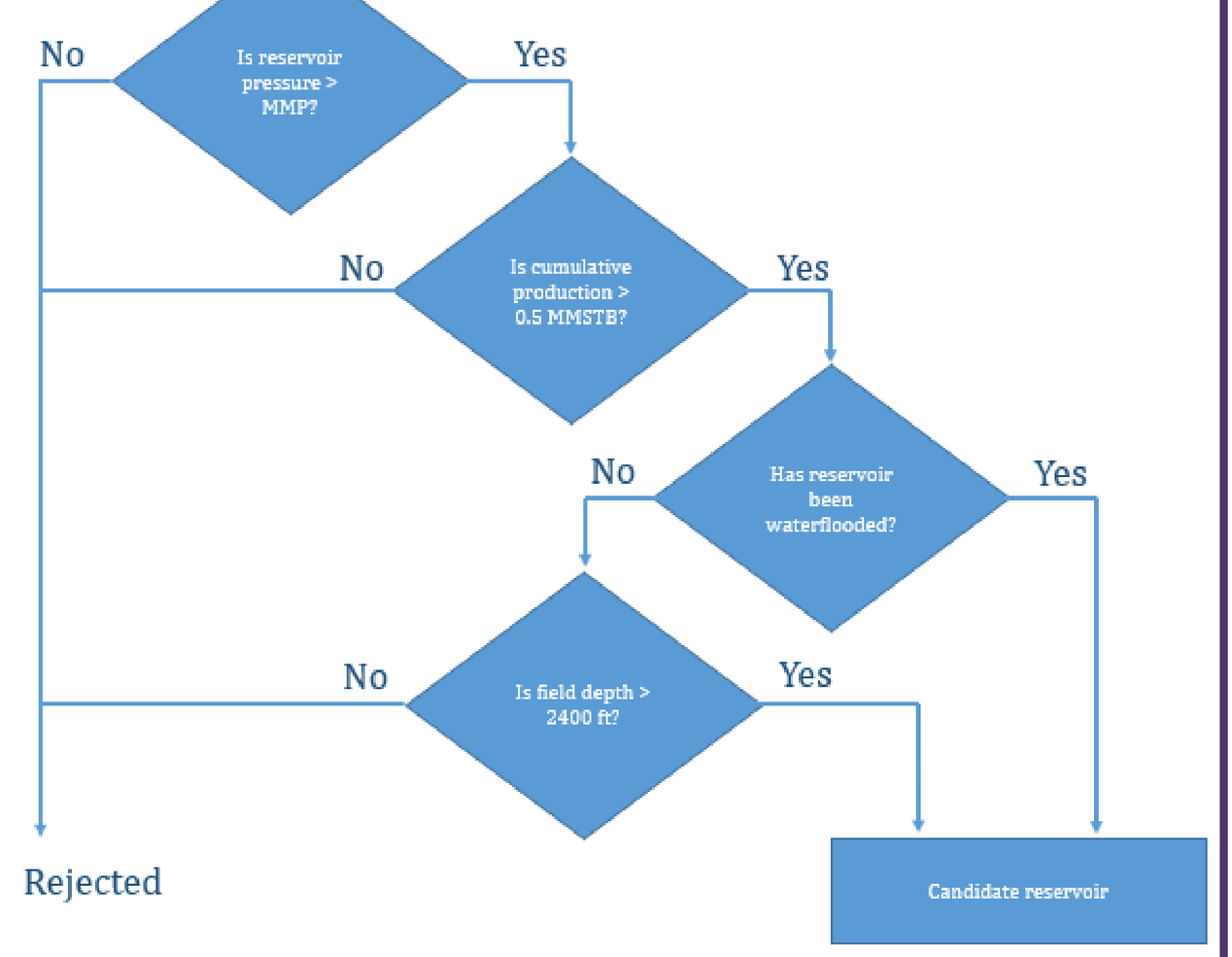


- Field depth
- Oil Gravity
- Minimum miscibility pressure
- Cumulative production

  } Applied
- Oil composition — No available data
- Original oil in place
- Residual oil

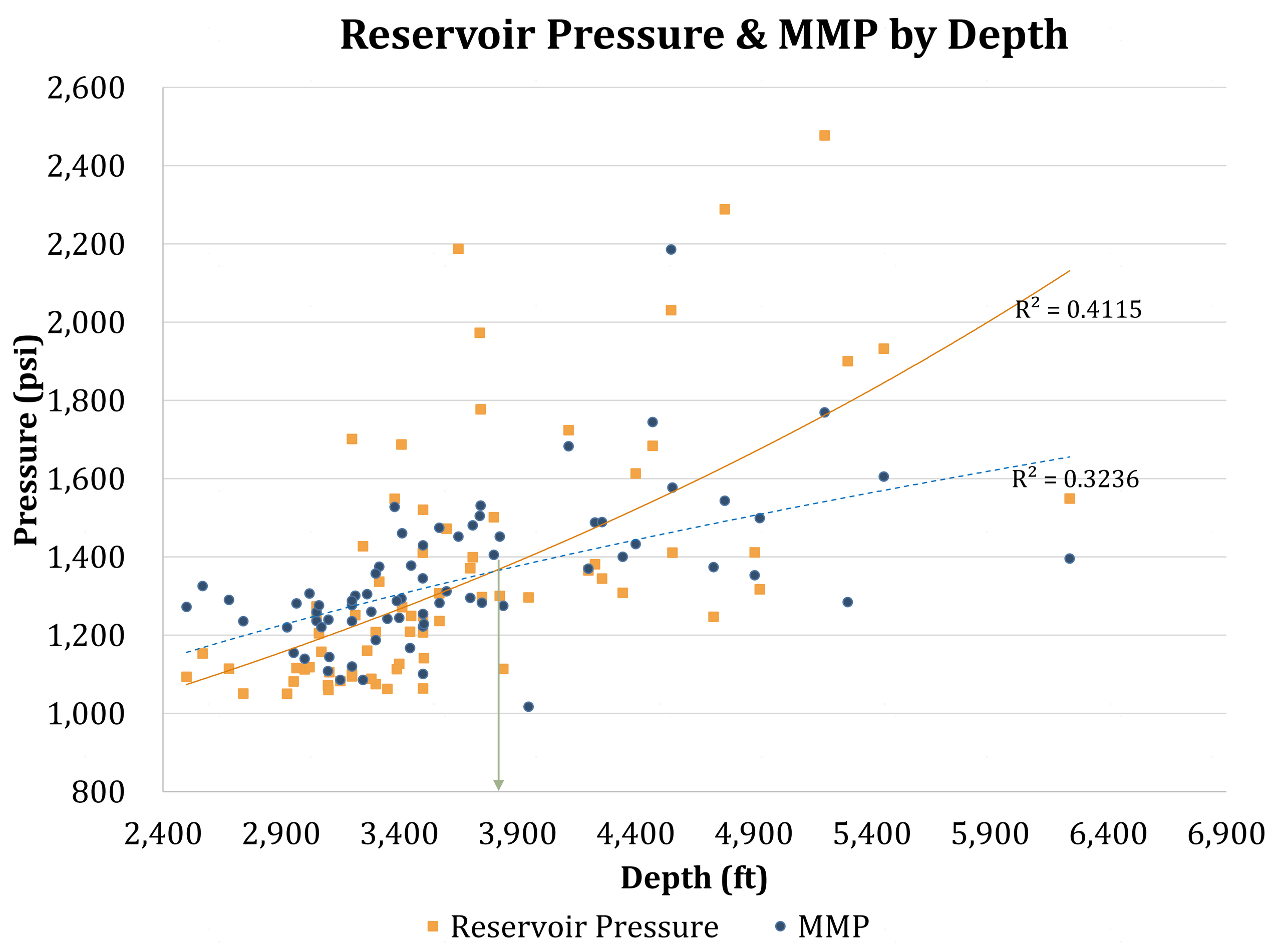
  Strongly dependent on economics.
- Porosity
- Permeability
- Net thickness

  Not considered due to inconsistent data.



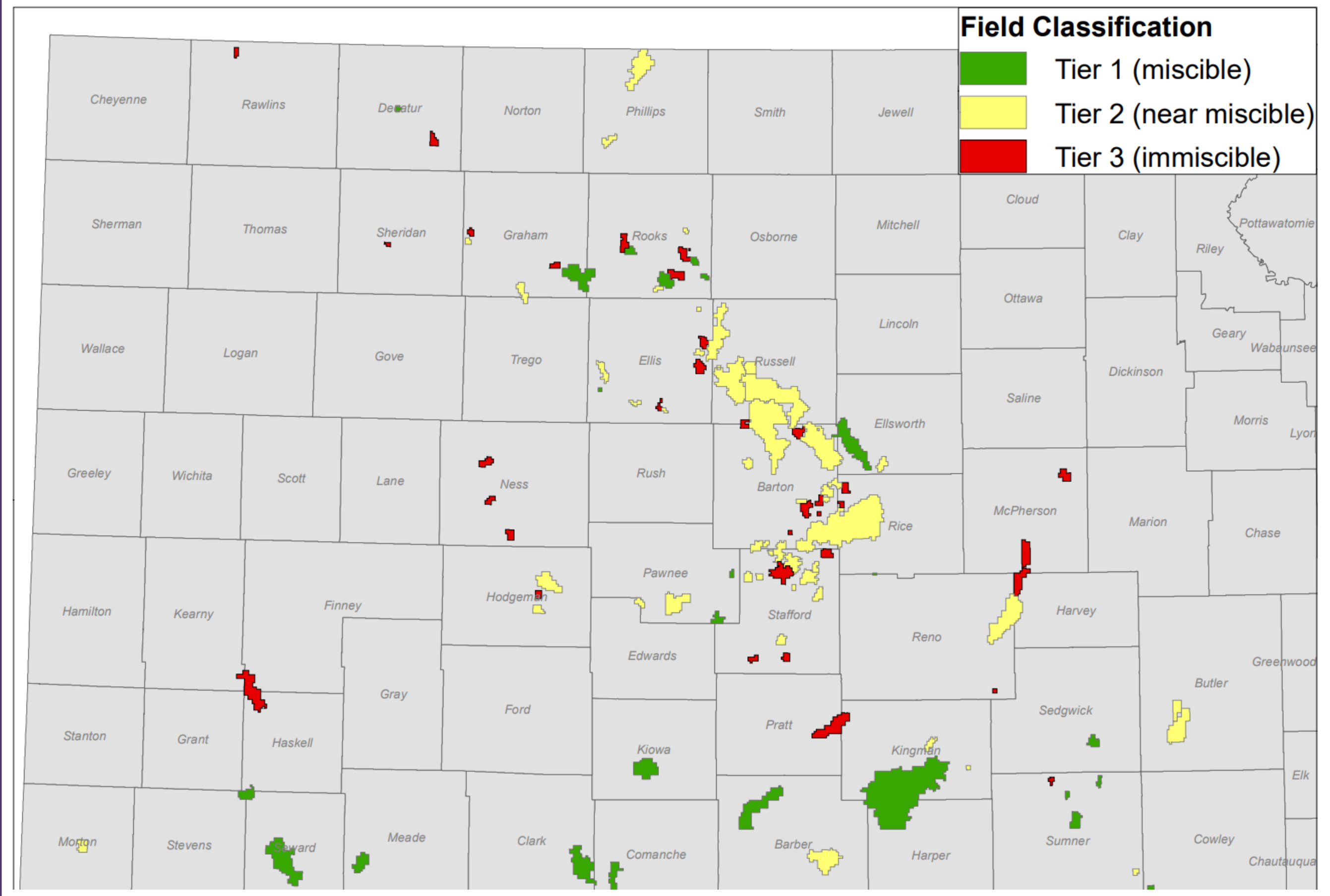
MMP Estimates

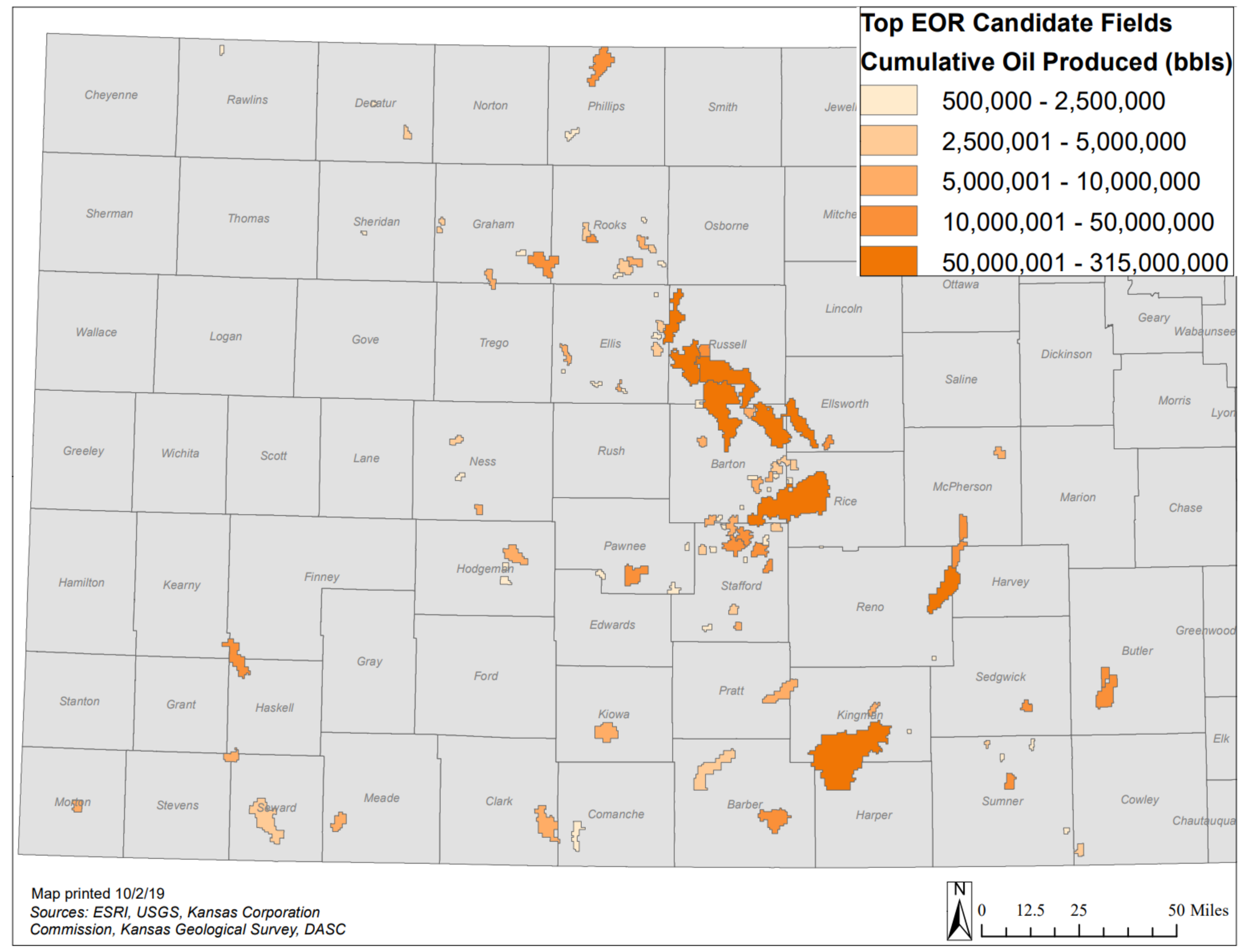
- MMP is the minimum pressure at which CO_2 will mix with reservoir oil to form a single phase.
- Cronquist correlation (Mungan, 1981)
- Miscible region > 3800 ft
- Near miscibility 3000< ft < 3800
- Immiscible region 2400< ft < 3000



Candidate Fields

Site #	County	Field	Cumulative Prod. (bbl)	Formation	Depth (ft)	Oil Gravity (API)	Reservoir Pressure (psi)	Ave. Reservoir Temp. (°C)	Est. MMP (psi)
1	Kingman	Spivey-Grabs-Basil	70,647,222	Mississippian/ Viola	4400	37	1,724	136	1,683
2	Ellsworth	Stoltenberg	55,556,387	Simpson/ Arbuckle	3333	37	1,427	86	1,086
3	Graham	Cooper	29,303,560	Arbuckle	3740	35	1,973	115	1,505
4	Sumner	Wellington	20,746,849	Mississippian	3650	42	2,188	130	1,452
5	Rooks	Barry	20,149,580	Arbuckle	3200	35	1,702	98	1,277
6	Sedgwick	Gladys	18,431,104	Simpson	3600	42	1,473	117	1,312
7	Seward-Stevens	Cutter	7,745,971	Morrowan/ Mississippian	5200	40	2,478	155	1,770
8	Clark	Harper Ranch	5,084,194	Lansing-Kansas City/Morrowan	5450	36	1,933	127	1,606
9	Seward	Evalyn-Condit	4,656,650	Chesterian/ Marmaton	6236	42	1,550	125	1,396
10	Rooks	Dorr	4,656,615	Lansing-Kansas City	3445	39	1,209	97	1,168





CO_2 Storage Capacity

- **Storage Capacity = ρCO_2 *ϴ *A *H *So*E / 2200**

QCO_2 is CO_2 sequestration capacity (metric tons), ρCO_2 is Density of CO_2 under reservoir conditions (lbs/ft3), ϴ is Porosity (%), A is Area (ft^2), H is Reservoir thickness (ft), So is Oil saturation (%) and 2200 is Conversion from lbs to metric tons.

County	Field	Oil Gravity (API)	Area (acre)	CO_2 Storage Capacity (Metric tons) P10	P90
Kingman	Spivey-Grabs-Basil	37	11750	13,949,620	69,748,098
Sumner	Wellington	42	5600	1,851,511	9,257,554
Seward-Stevens	Cutter	40	5440	1,930,552	9,652,759
Rooks	Plainville	34	6240	9,522,330	47,611,650
Sumner	Seydell	40	1680	555,453	2,777,266

- Total CO_2 stored in all 5 fields is approximately between 27 – 139 million metric tons

On-going Work

- Perform geochemical analysis using PHREEQC simulator.
- Study changes in produced water composition prior to and after CO_2 injection.
- Evaluate the effect of CO_2 addition to mineralization.

Acknowledgements

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