CARBON CAPTURE, UTILIZATION & STORAGE CONFERENCE

APRIL 10-13 | MCCORMICK PLACE WEST | CHICAGO, IL

GEOCHEMICAL MONITORING SURVEY RESULTS FROM CO_2 EOR AT WELLINGTON FIELD IN SOUTH KANSAS

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Participants

BEREXCO

KU KANSAS GEOLOGICAL SURVEY
The University of Kansas

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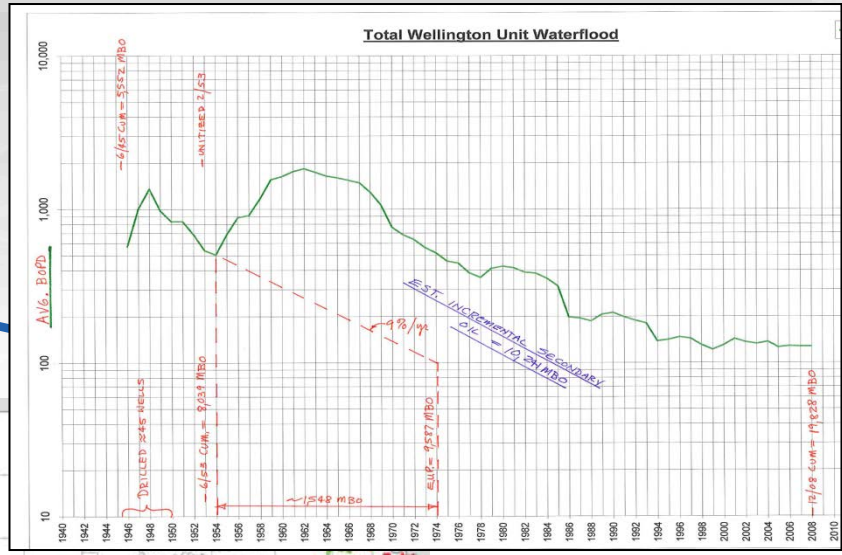
Outline

- Project introduction
- Web-based interactive database
- Geochemical monitoring survey
- Some results and data analysis

Wellington Field, South KS



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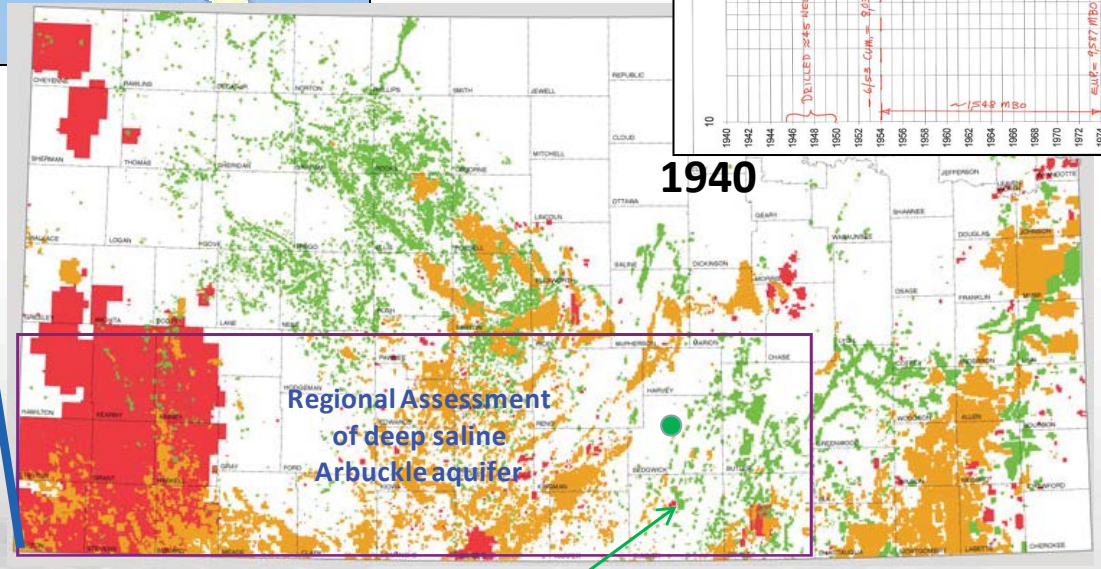
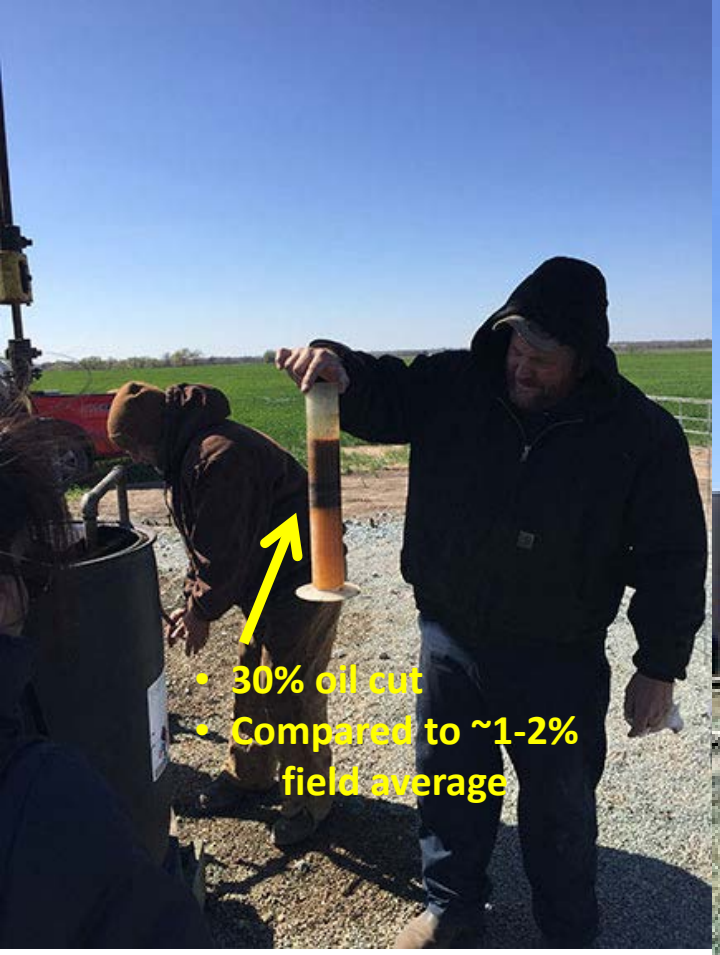
2009



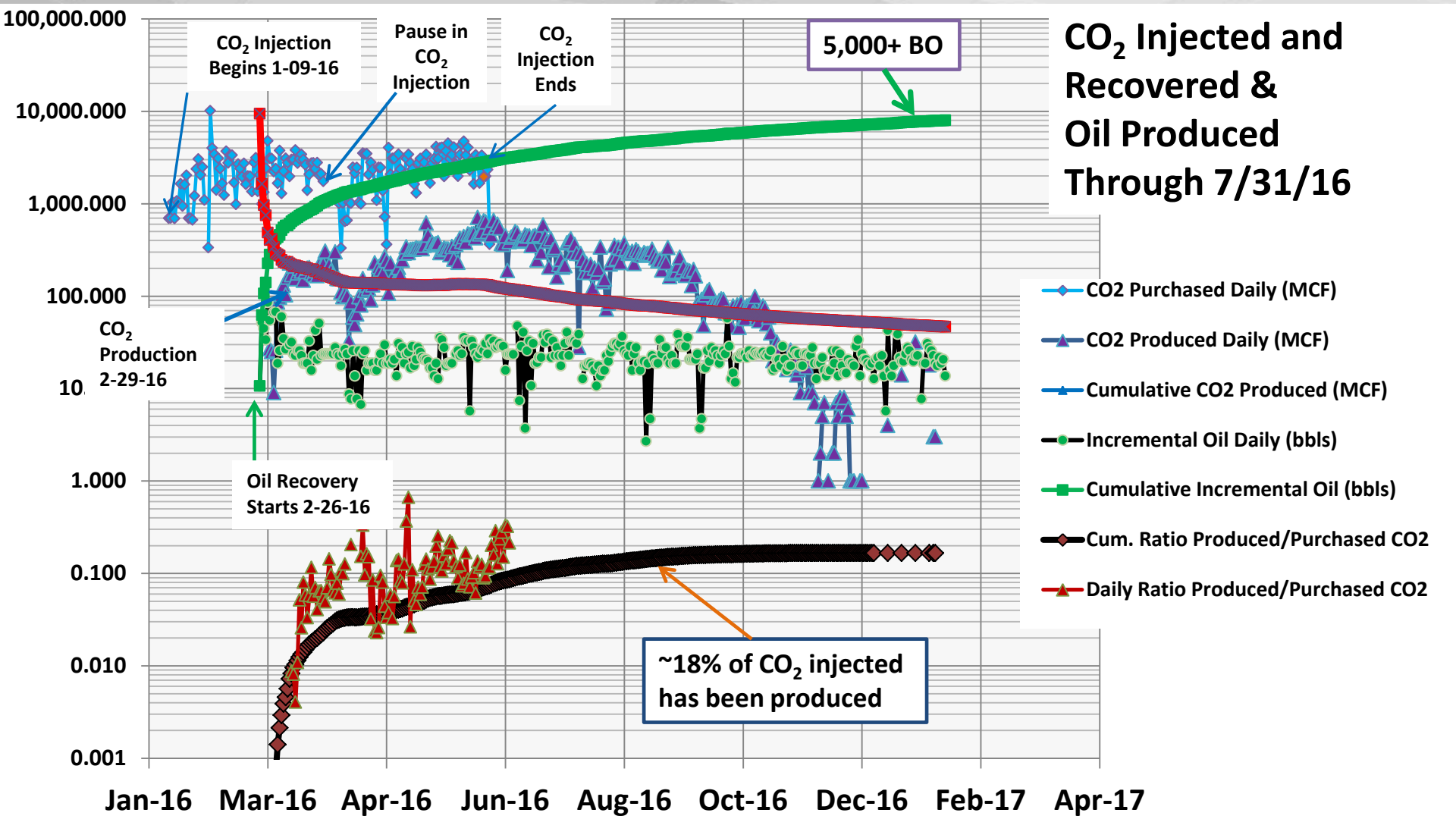
Plan for CO_2 EOR Pilot

- Find, characterize, and prepare oil field
- Find CO_2 source
  - Initially, ethanol plant ⟹ multiple sources
- Develop strategy for resource recovery through reservoir modeling
  - Several revisions
- Obtain a permit and drill a new injection well
- Organize surface infrastructure and deliver CO_2
  - Truck delivery
- Inject ~~~26,000~~ ~20,000 tones of CO_2 at 100-150 tones/day
- Monitor and manage CO_2 plume
- Vent produced CO_2



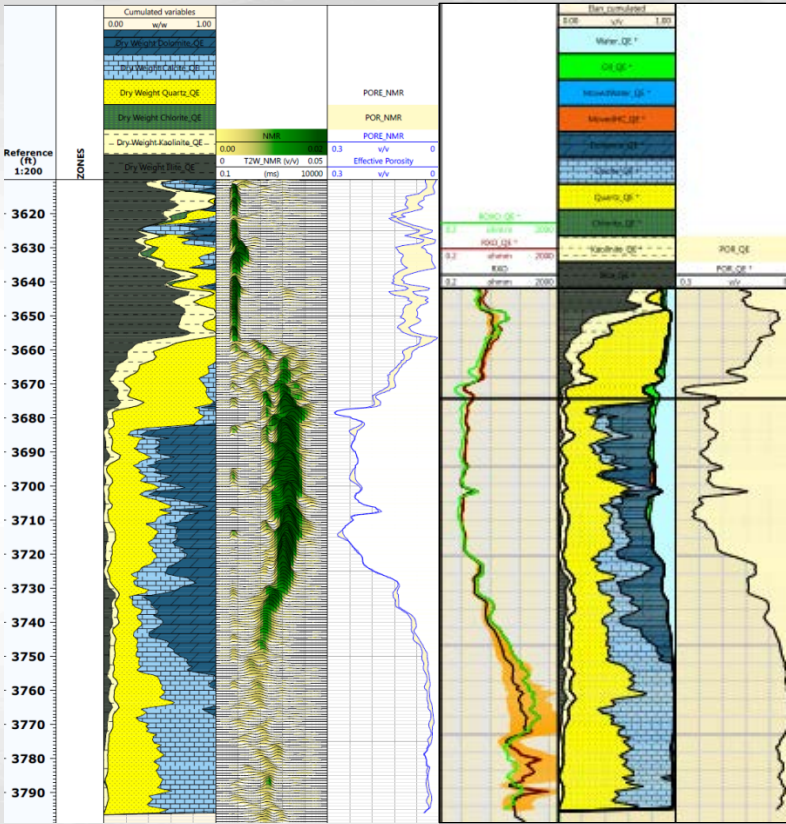
Wellington Field small scale CO_2-EOR
Jason Bruns above (Caanon Well Services) and Dana Wreath upper right (VP *Berexco, LLC*) with KGS staff

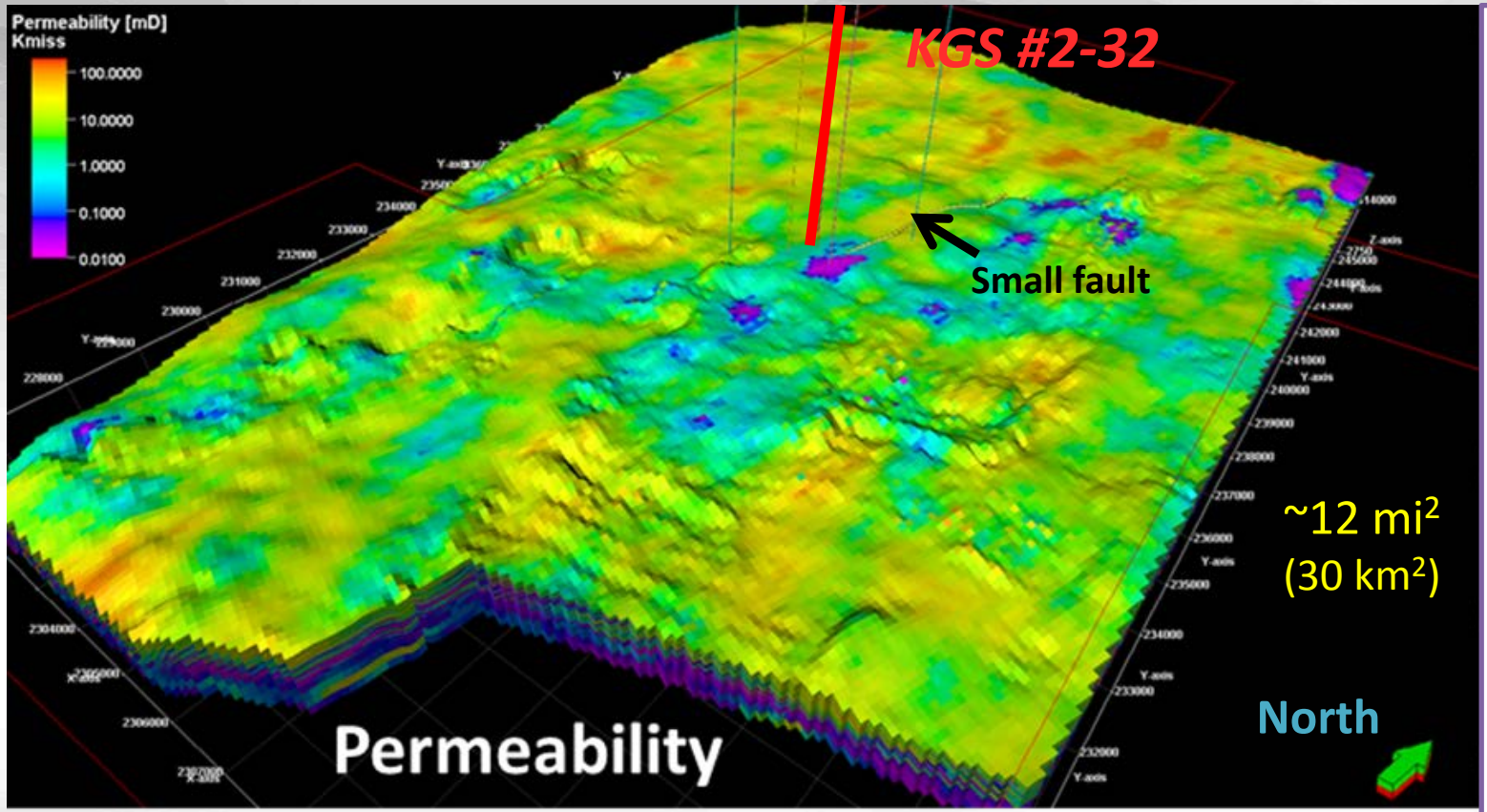
Operations: CO_2 Delivery and Surface Facilities

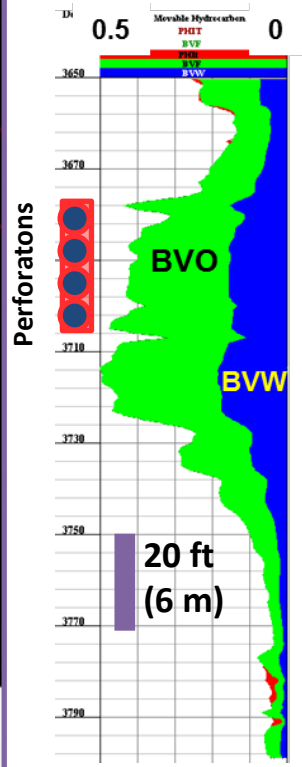

CO_2 Injection Begins 1-09-16
Pause in CO_2 Injection
CO_2 Injection Ends
5,000+ BO
CO_2 Production 2-29-16
Oil Recovery Starts 2-26-16
~18% of CO_2 injected has been produced
CO_2 Injected and Recovered & Oil Produced Through 7/31/16
CO2 Purchased Daily (MCF)
CO2 Produced Daily (MCF)
Cumulative CO2 Produced (MCF)
Incremental Oil Daily (bbls)
Cumulative Incremental Oil (bbls)
Cum. Ratio Produced/Purchased CO2
Daily Ratio Produced/Purchased CO2
100,000.000
10,000.000
1,000.000
100.000
10
1.000
0.100
0.010
0.001
Jan-16
Mar-16
Apr-16
Jun-16
Aug-16
Oct-16
Dec-16
Feb-17
Apr-17

Reservoir Characterization

- Very old Neutron logs with or without resistivity logs for all wells
- 16 wells with complete suites of resistivity and porosity logs
- New wells drilled by KGS have a full set of modern logs
- Core is available from KGS #1-32
  - Porosity/permeability
  - Geochemistry
  - Geomechanical data
- 3D Seismic
- Formation fluids analysis



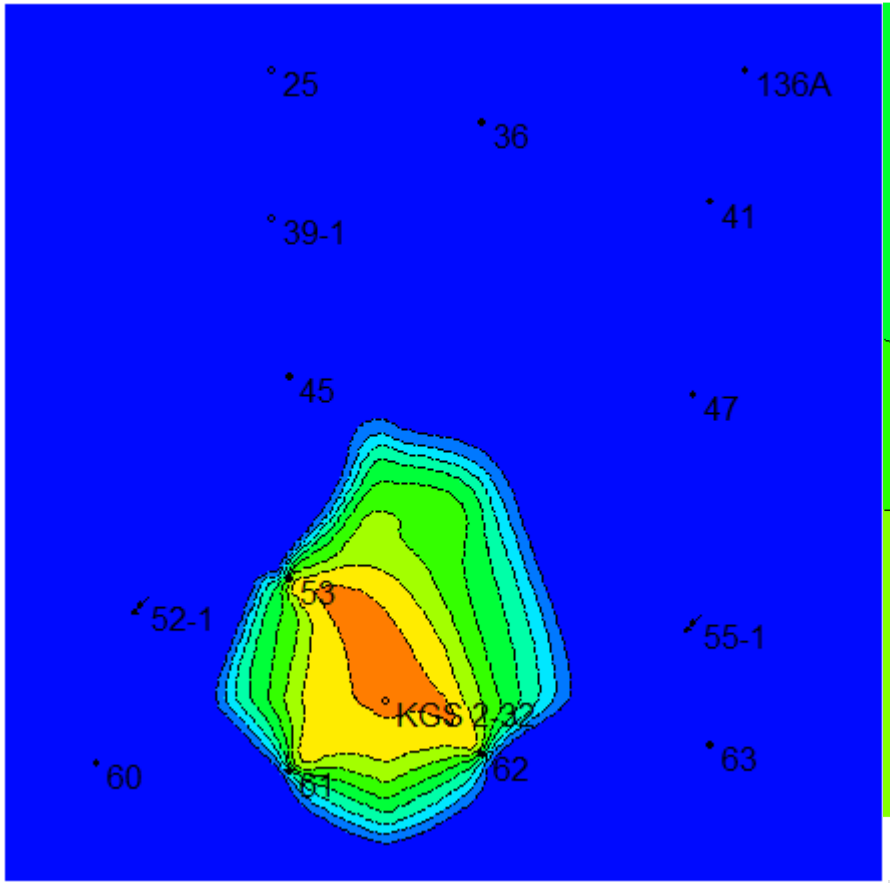




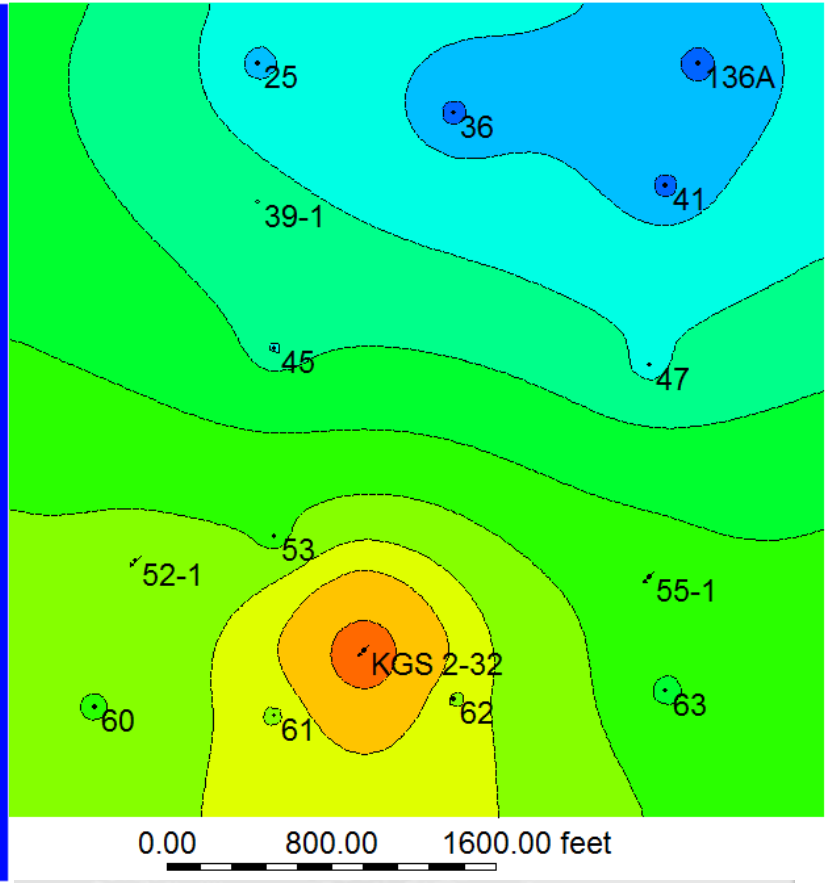
- Petrel map of permeability distribution in the Mississippian dolomite
- CO_2 injection well is red vertical line
- Lower permeability noted east and south of the injection well, Berexco Wellington KGS #2-32
- Residual oil saturation in cored injection well averages 23%

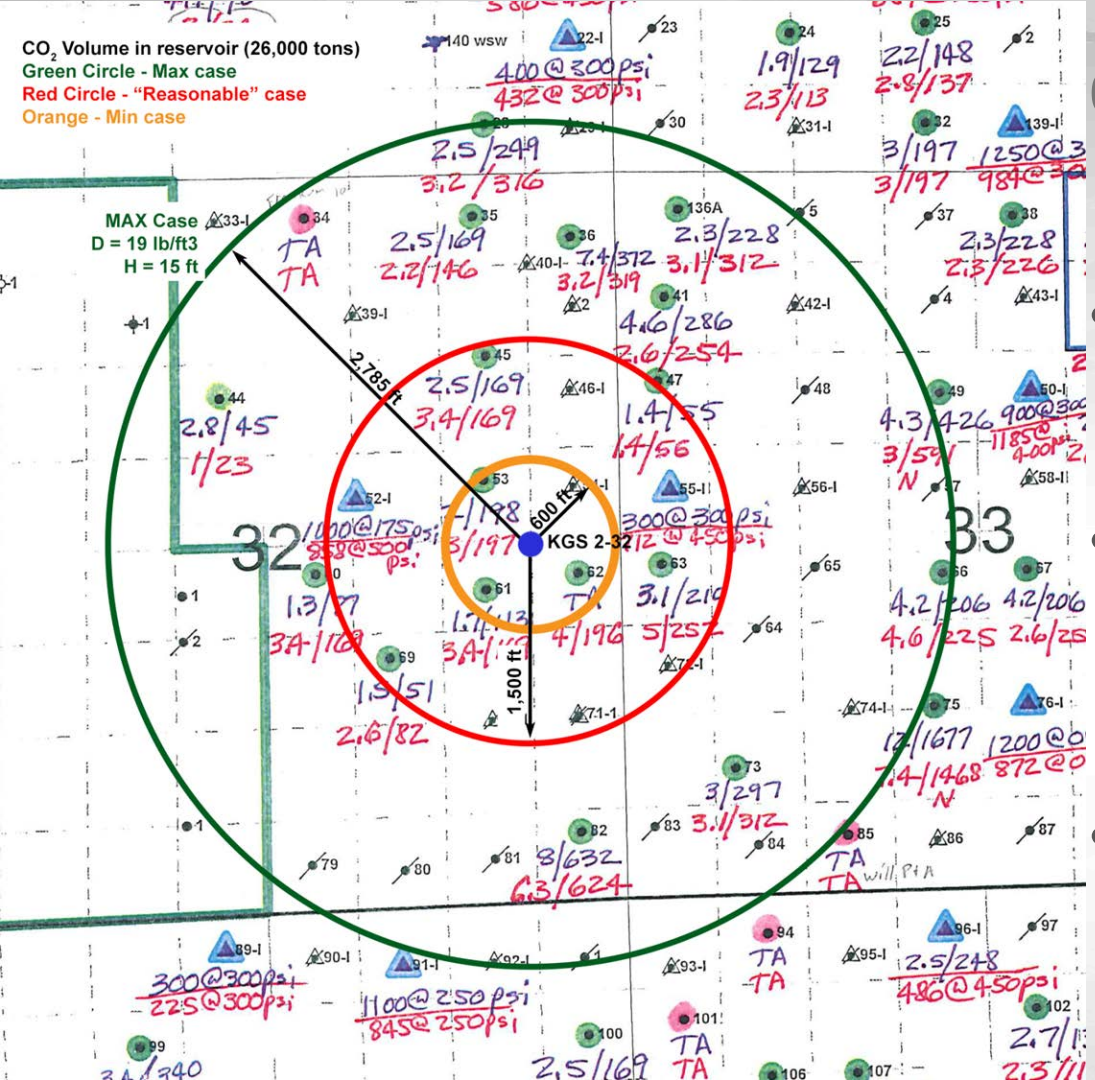
J. Rush

Forecasted CO_2 Movement in Reservoir



Forecasted Pore-Pressure Distribution at the Start of CO_2 Injection
Required miscibility pressure is ~1650





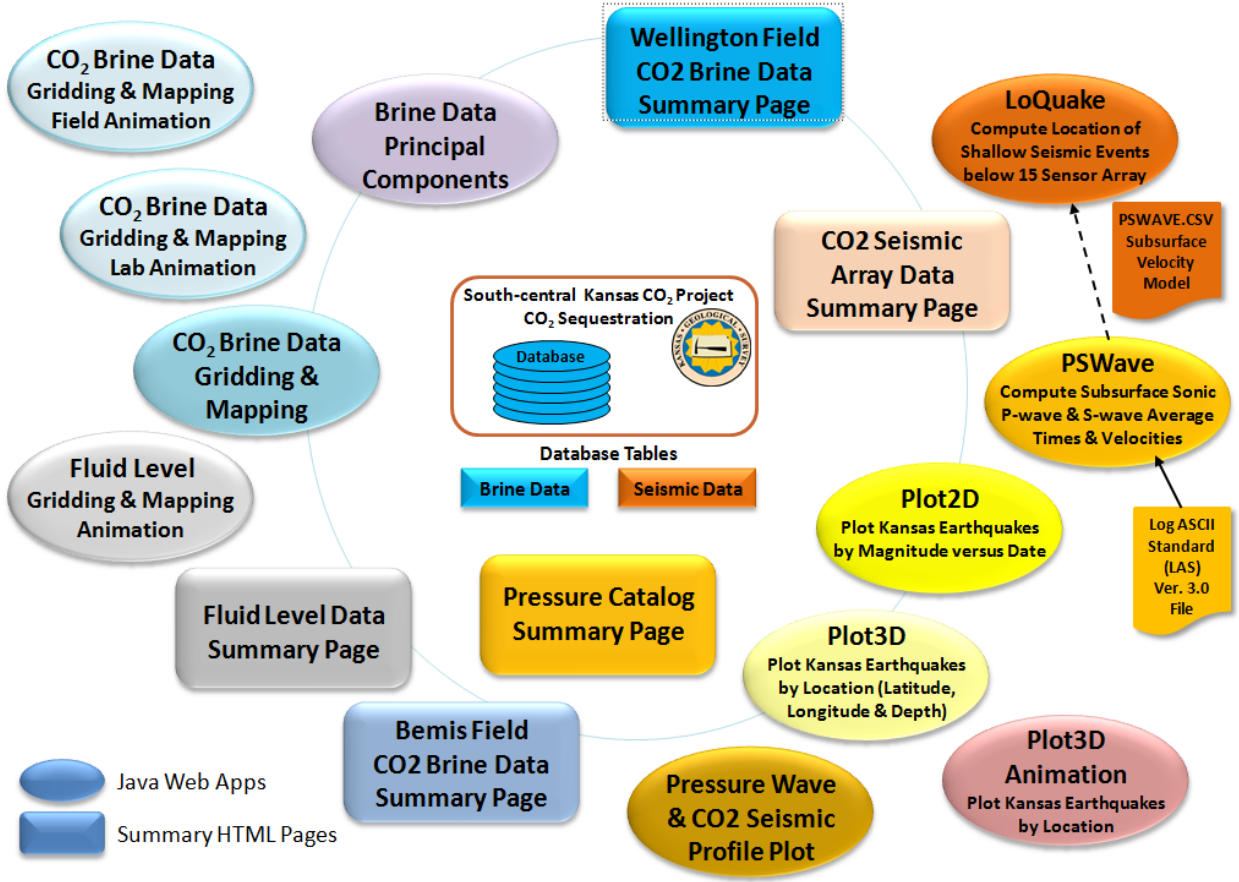
Fluid Monitoring

- Two geochemical data sets
  - Baker&Hughes
  - KU/KGS
- Water chemistry
  - Alkalinity/pH/TDS – on site
  - Cations/anions - Lab
  - Microbial - Lab
- Production history
  - Oil/water/pressure
  - CO_2 account

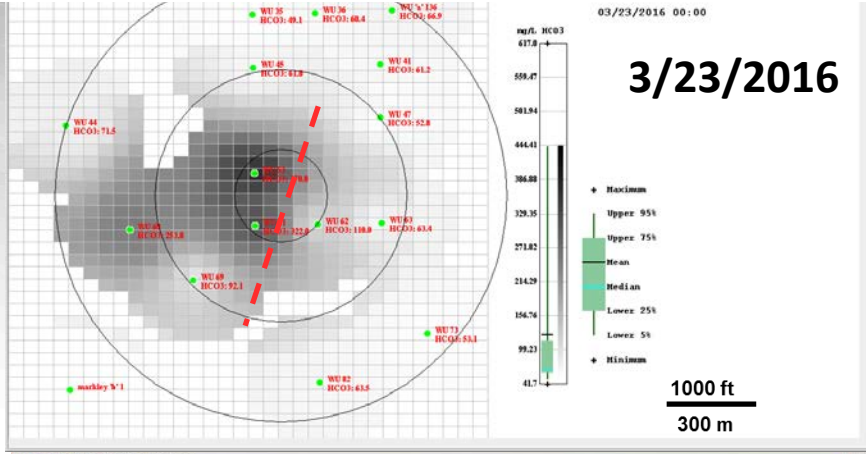
South-central Kansas CO_2 Project
CO_2 Sequestration
Summary Pages and Web Apps

Select the bubble button below to display respective module.

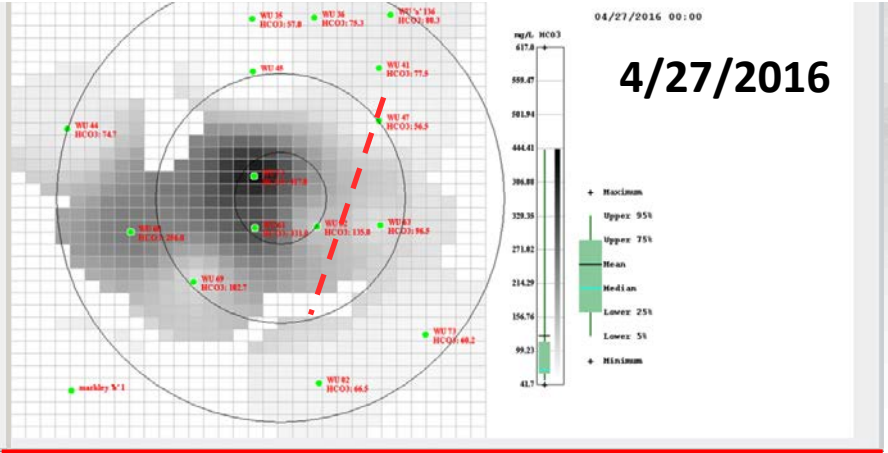
Web Applications Built to Display and Analyze Data "*in Real-Time*" by the Team During Monitoring → ***time lapse maps, cross plots, analytical tools, csv download***



Time Lapse Alkalinity -- During and Post CO_2 Injection



3/23/2016



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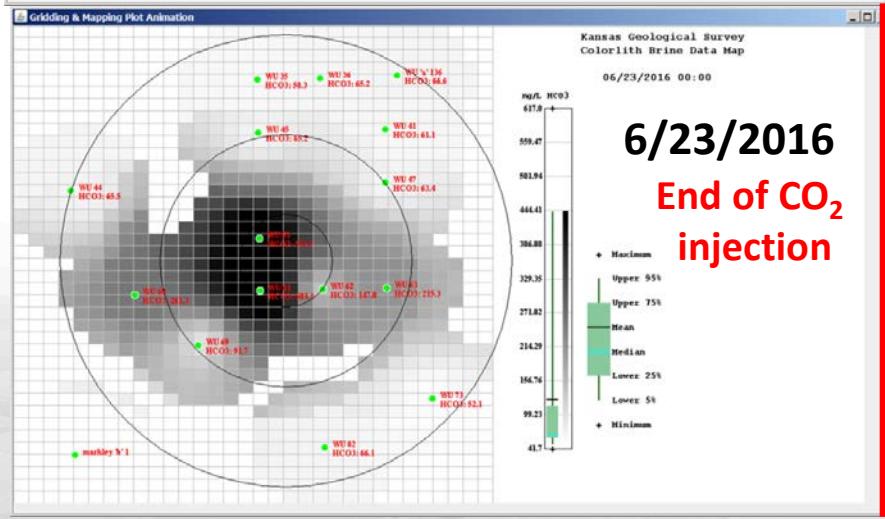
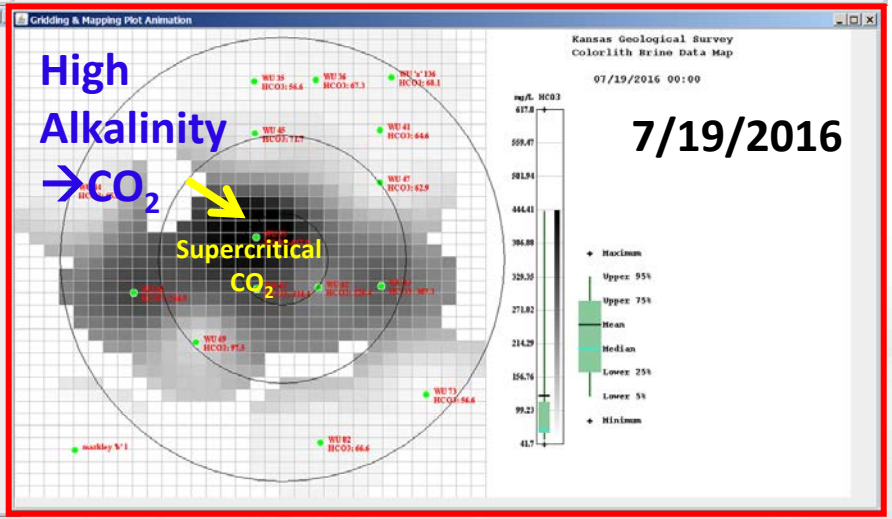


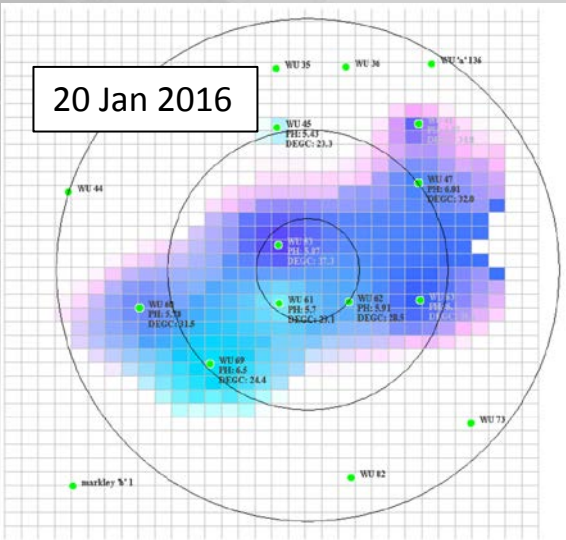
6/23/2016

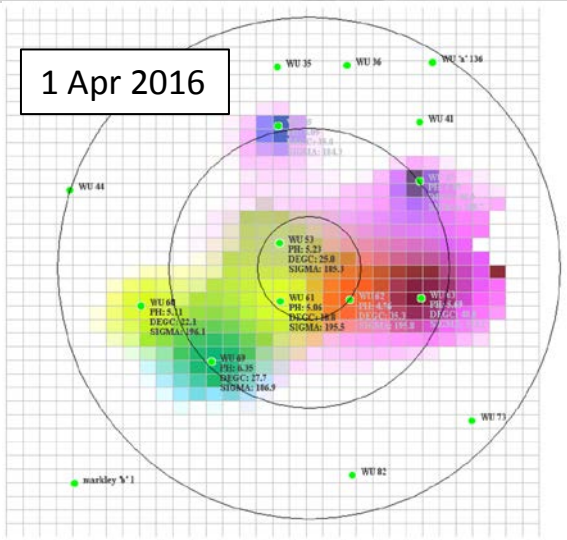
End of CO_2 injection

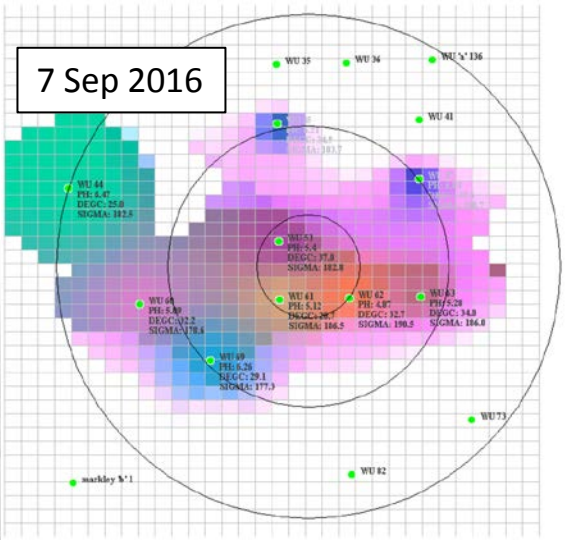


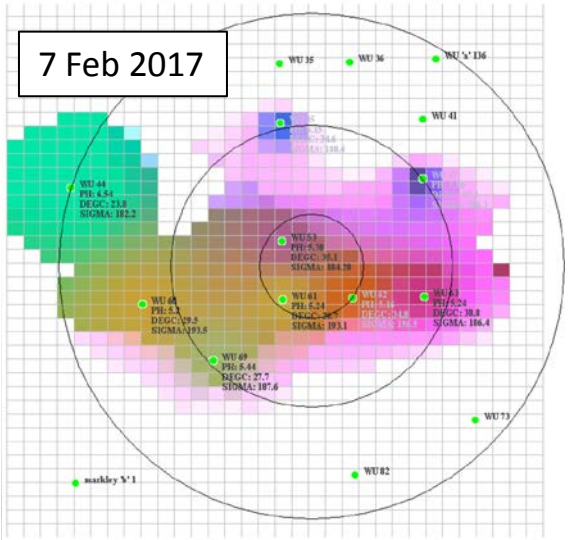
7/19/2016

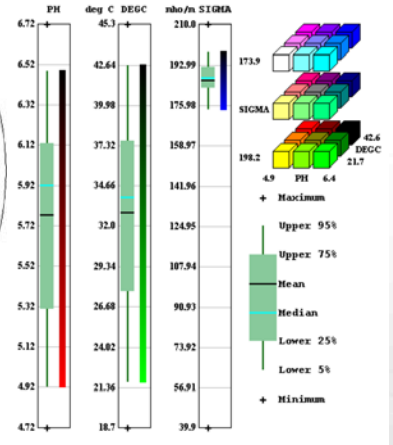
Mapping Animation Web Applet – Nearest Monitoring Wells







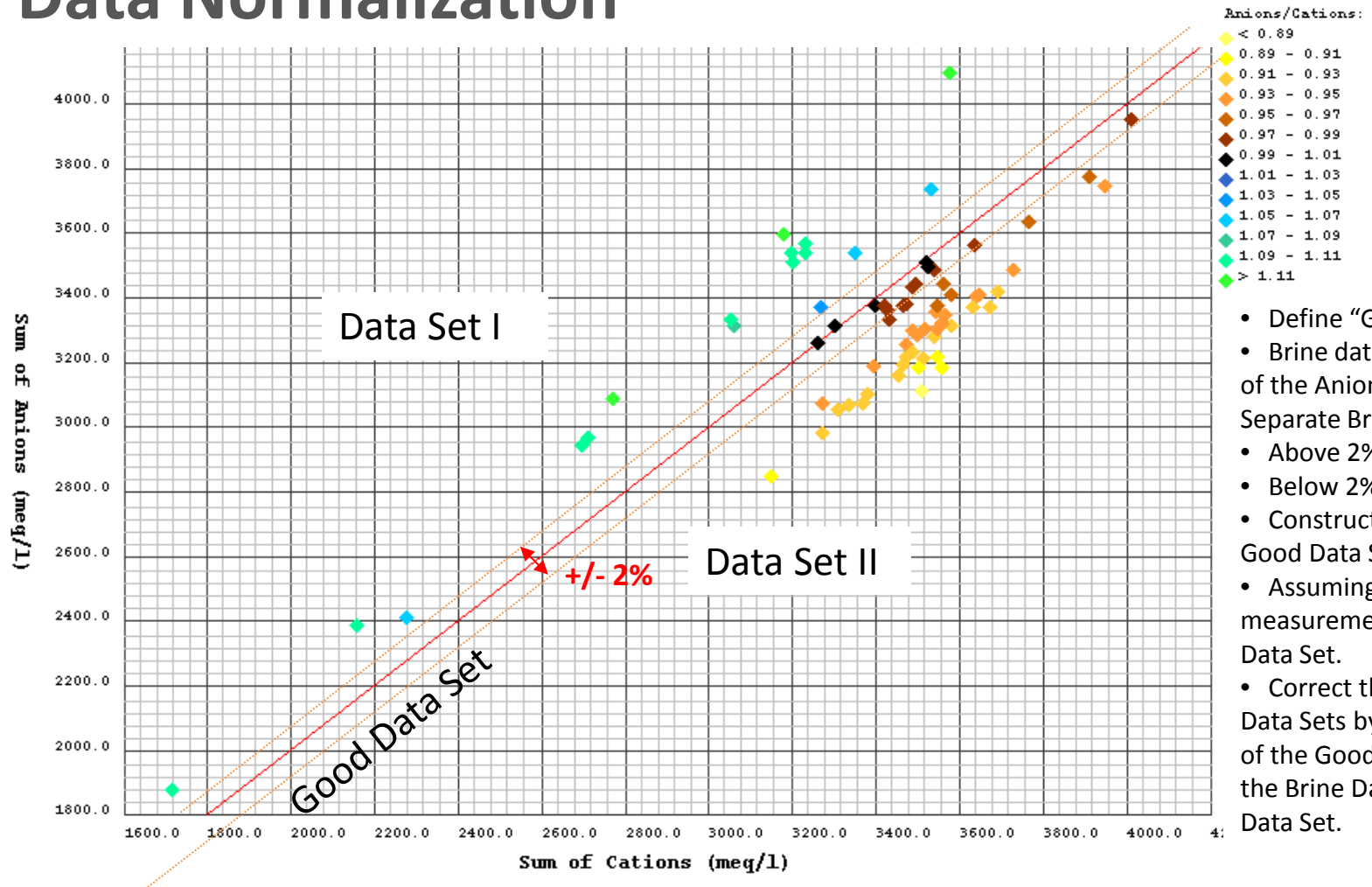




Field Test Data

- PH
- Temperature [deg C]
- Conductivity [mho/m]

Data Normalization

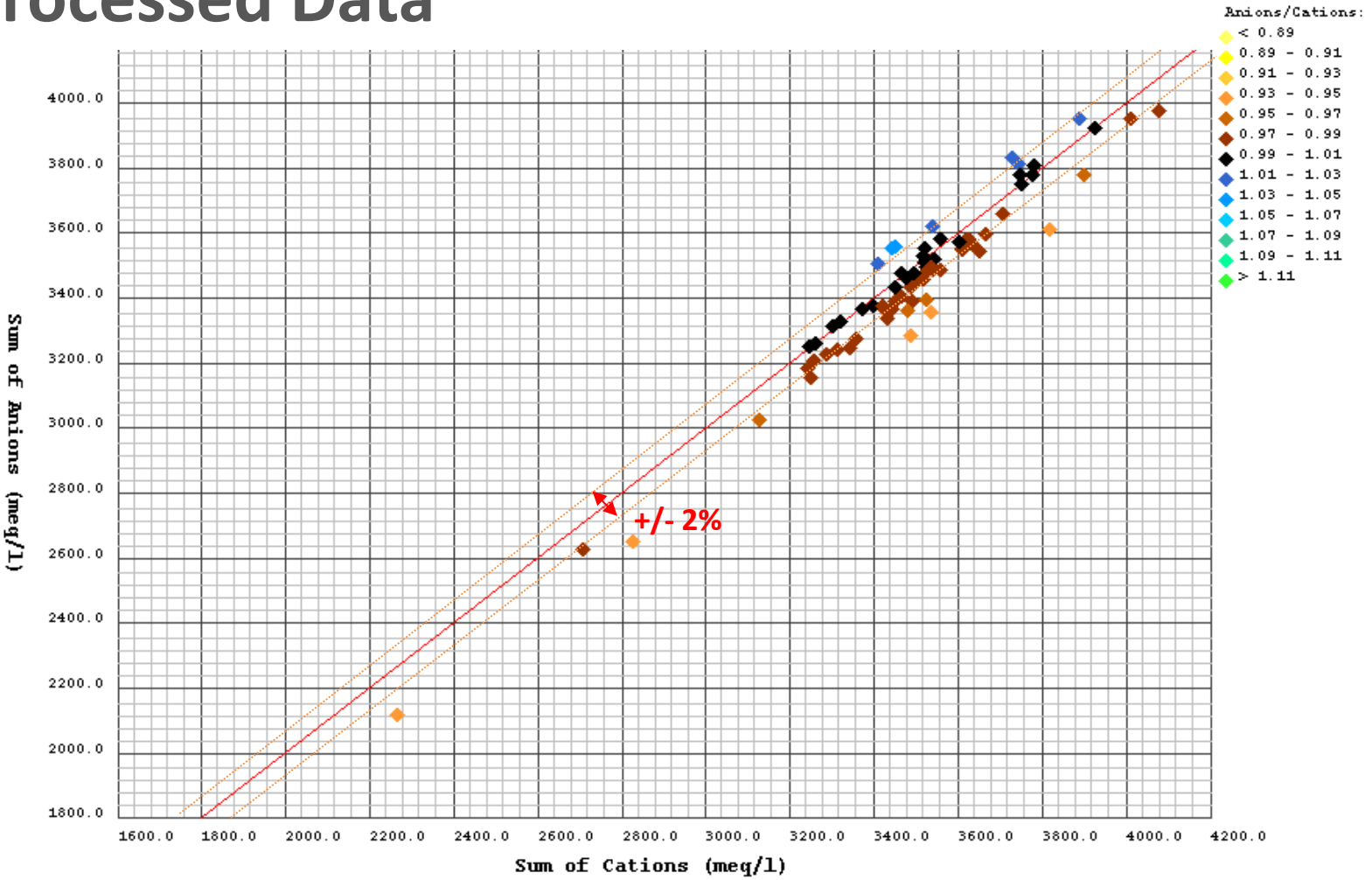


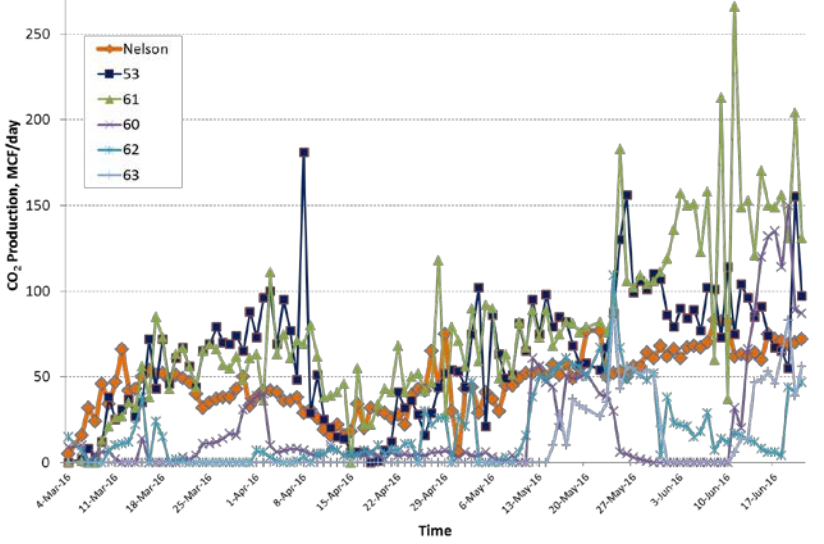
- Define “Good” Data Set
- Brine data falling between +/- 2% of the Anions/Cations Ratio

Separate Brine Data to:

- Above 2% of the Good Data Set
- Below 2% of the Good Data Set
- Construct an Eigenvector for the Good Data Set
- Assuming that the data has a measurement “Error” to the Good Data Set.
- Correct the Above and Below Data Sets by using the Eigenvector of the Good Data Set to “correct” the Brine Data to the define “Good” Data Set.

Reprocessed Data

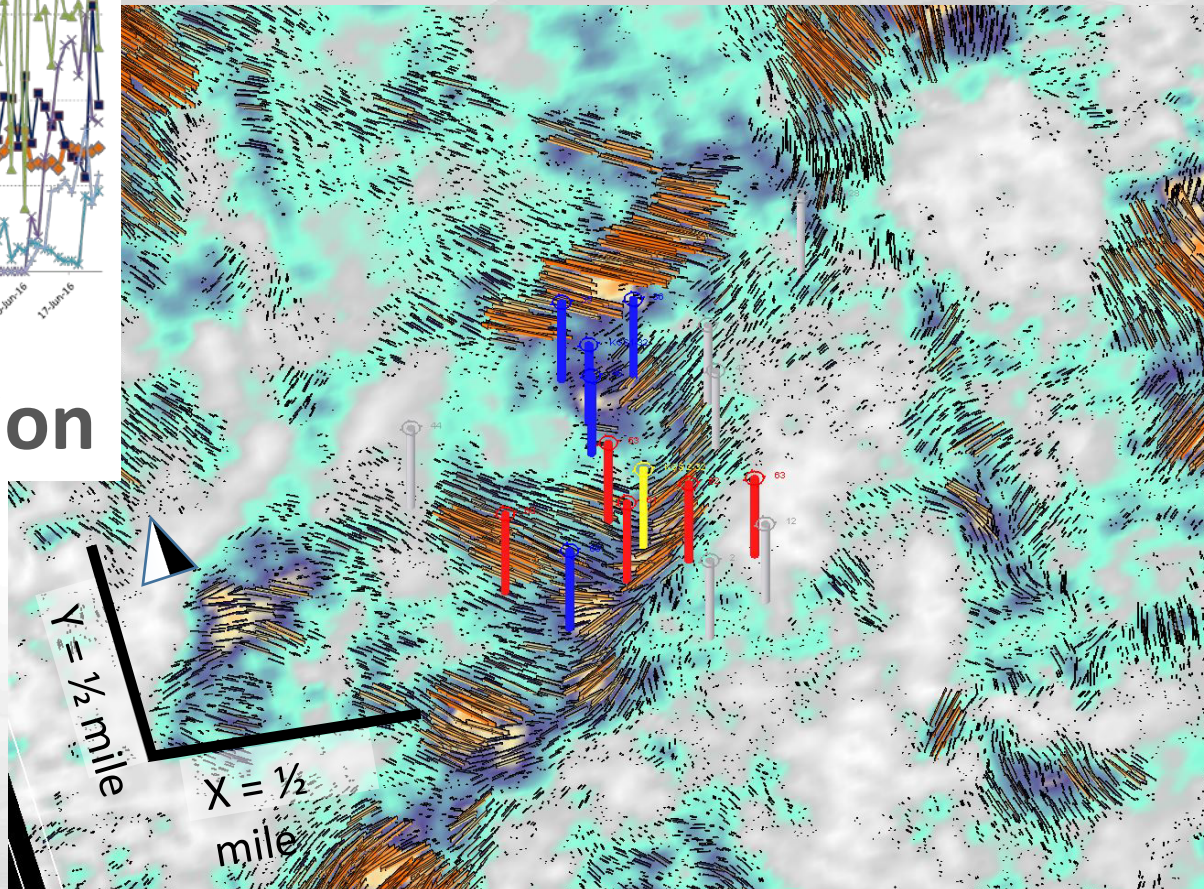




Data cross-verification

T_5 = June 17, 2016

- KGS 2-32 Injection well
- Significant CO_2 production
- Detection of CO_2
- No detection of CO_2



Summary

1. CO_2 breakthrough could be monitored with alkalinity and pH; however, lowered alkalinity and pH did not always mean that well would ever produce CO_2
2. Fractures and faults in carbonate reservoir greatly influence flow but not always as expected and fracture volume plays critical role
3. “Real” real-time monitoring with geochemistry is unlikely; however it is relatively cheap and effective verification tool
4. Sample processing conditions and procedures influence results
5. Cation/anion and microbial data is still in processing and new findings are coming

Acknowledgements & Disclaimer

Acknowledgements

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Questions?