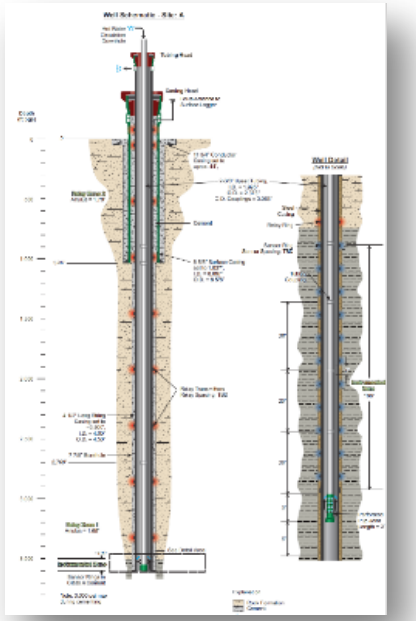
Downhole Sensors and Wellbore Integrity Monitoring with Legacy Oil & Gas Wells for Managing Greenhouse Gas Emissions



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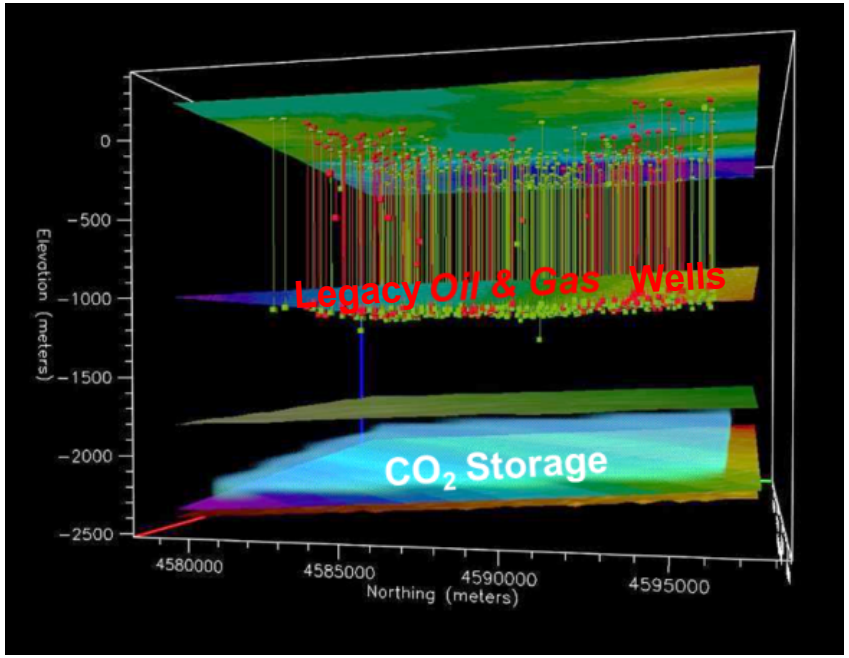
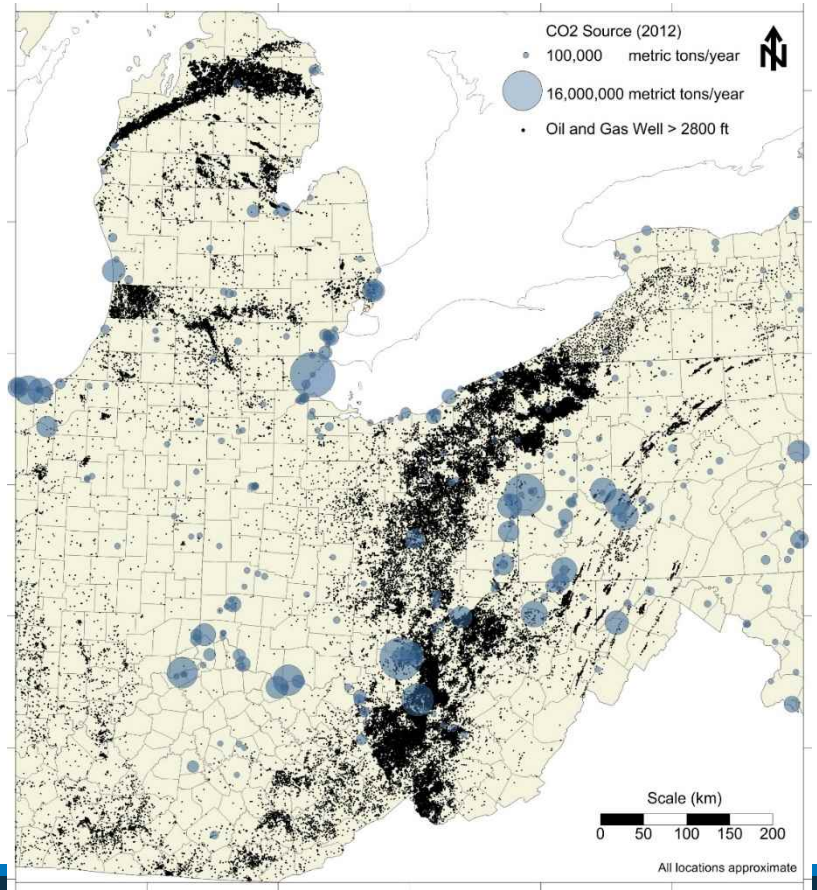
Downhole Monitoring

- Monitoring CO_2 storage, methane leakage, well integrity is a challenge for industry.
- Legacy oil & gas well may be utilized for monitoring.

Legacy oil & gas wells may be used for monitoring CO_2 storage or Methane Leakage Monitoring





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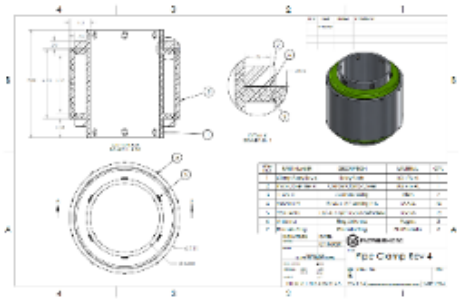
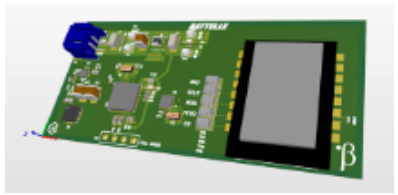
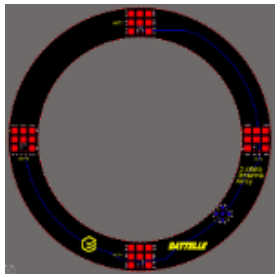
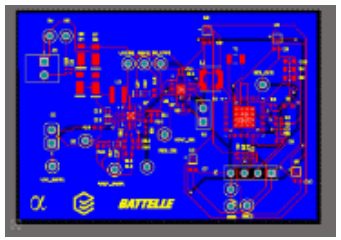
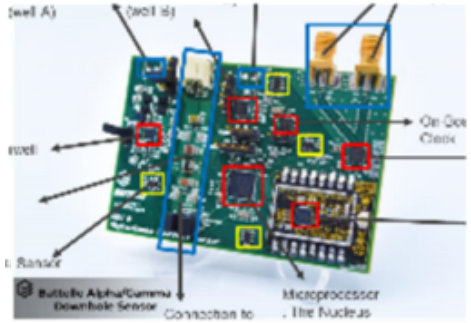
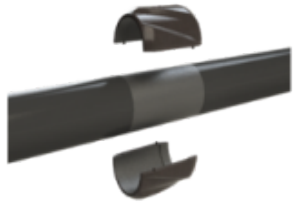
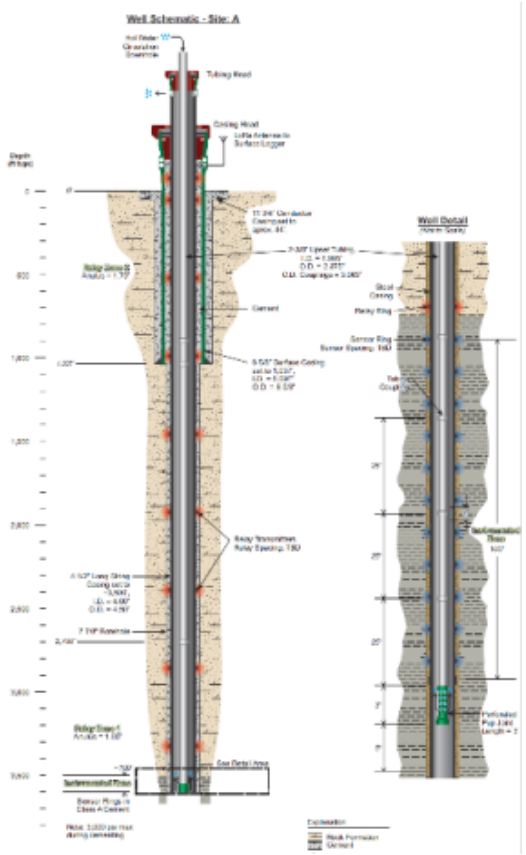
Downhole Sensor Design

- Downhole temperature sensor “ring” developed to facilitate wireless RF data transmission up well, wireless power, & installation in legacy O&G wells via typical centralizers.

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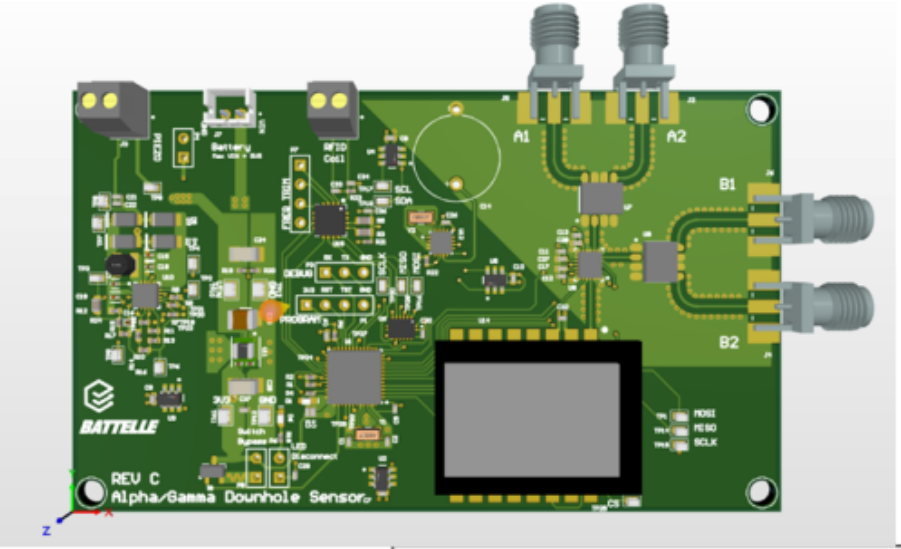
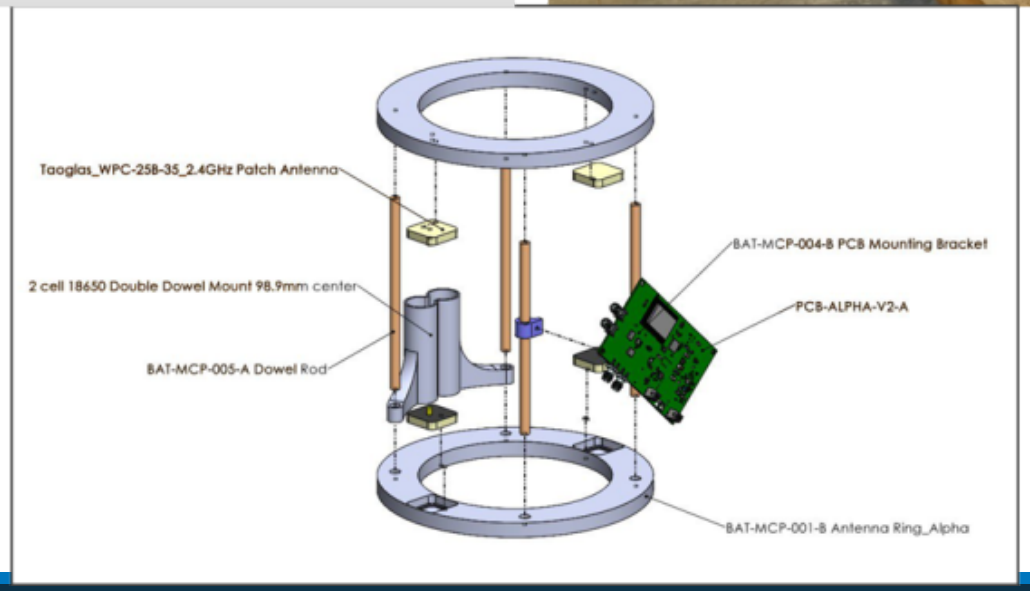
Sensor / Relay Rings





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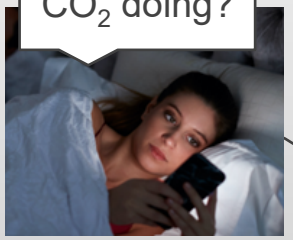
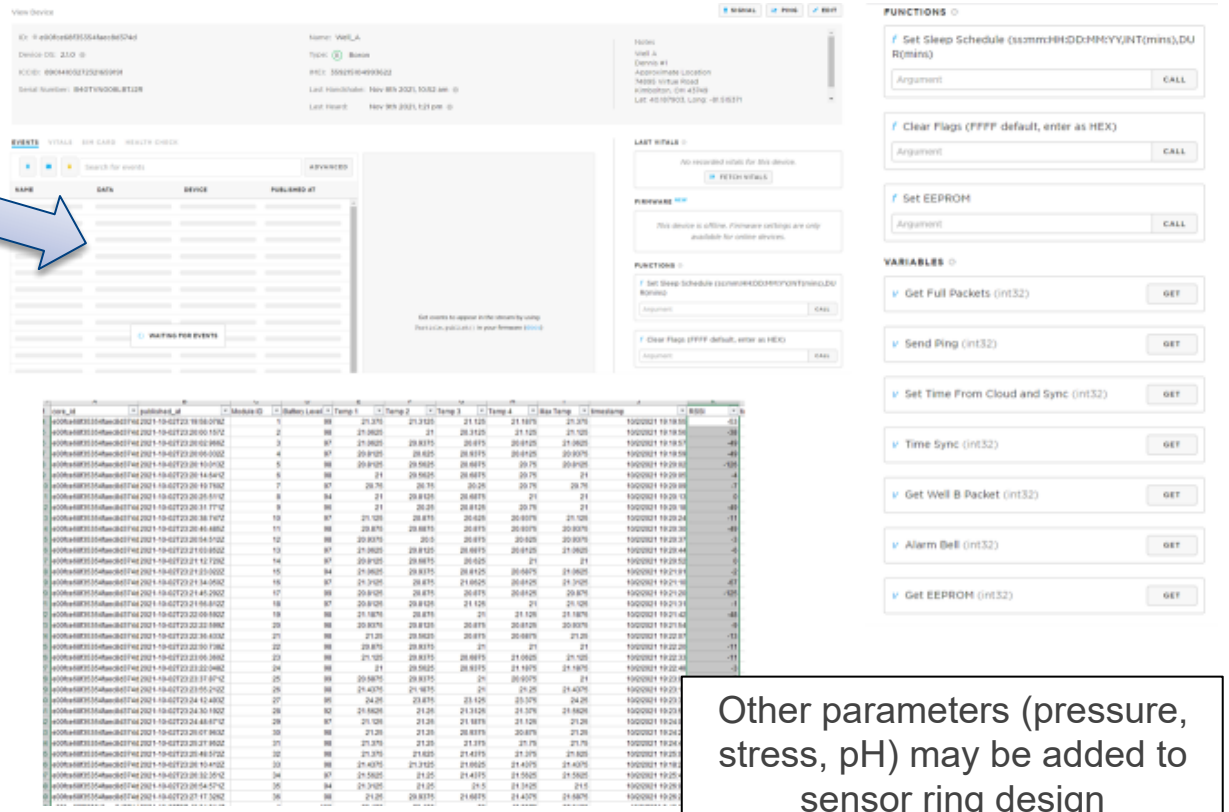
Logging Data into the cloud



How is my CO_2 doing?

Real Time Downhole Temperature Data at each sensor ring location



Automated Surface Data Logger

Other parameters (pressure, stress, pH) may be added to sensor ring design

Downhole Sensor System

- Sensor rings installed on 4 ½” casing.
- Composite centralizer clamped over sensor rings to protect electronics, options for wireless charging downhole.

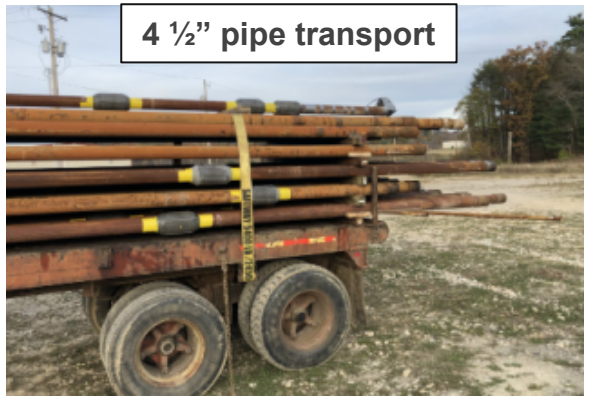
Sensor ring testing

Centralizer Install

Wireless Powering Demonstration

Sensor ring install

4 ½” pipe transport



Downhole Sensor Well Testing

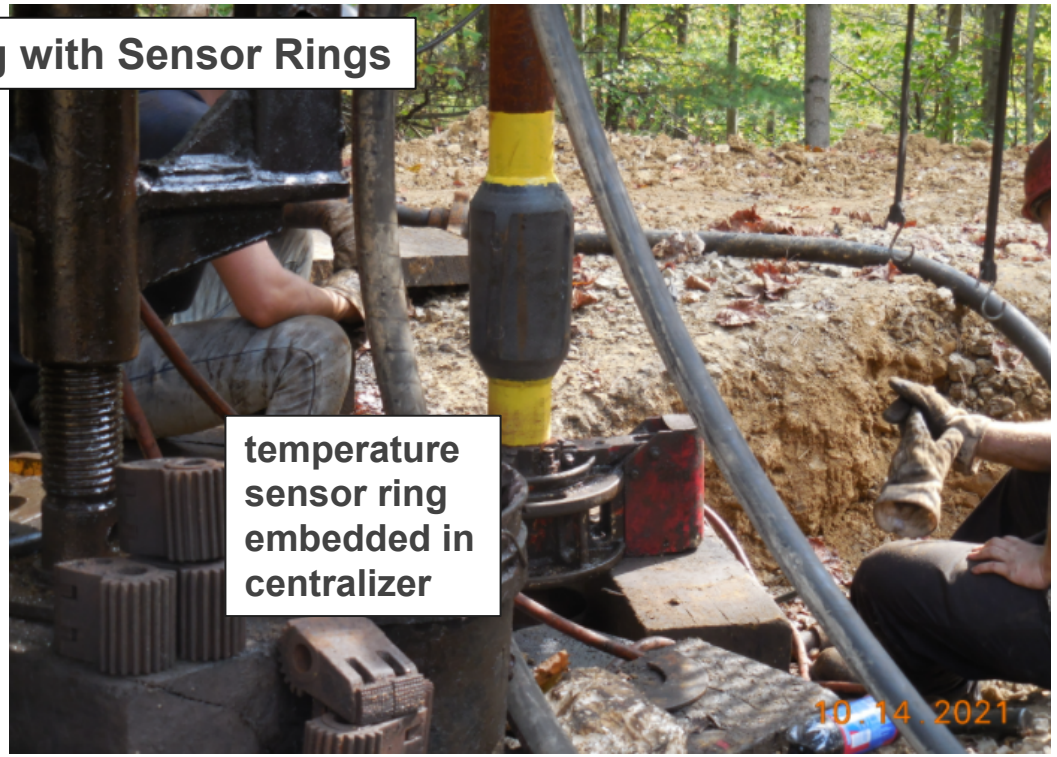
- Sensor system installed in legacy oil & gas wells to test function using **temperature sensors** for validation.
- Utilizes existing infrastructure to reduce costs, impact.

Running 4 ½" casing with Sensor Rings

Downhole Sensor Well Testing

- Sensor rings run on 4 ½” casing to 2500 ft. Sensor relays set at 40-80 ft spacing to depth of 2500 ft.
- Well cemented to surface in 2-stage job and CBL run to confirm cement.

Running 4 ½” casing with Sensor Rings



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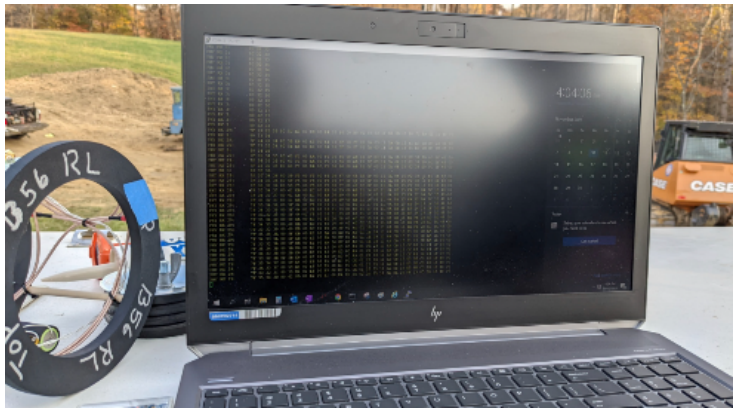
Downhole Sensor Well Testing

- System allows long term, automated monitoring of downhole temperature (other parameters in future).



Well Integrity Testing

- Well integrity diagnosis important for methane leakage, CO_2 storage, natural gas storage, and orphan well safety.
- Example, 1 million legacy oil & gas wells in Midwest U.S.

Source: Drake Well Museum.

Source: Morrow County Oil Boom. 1994. Ohio Geological Society.

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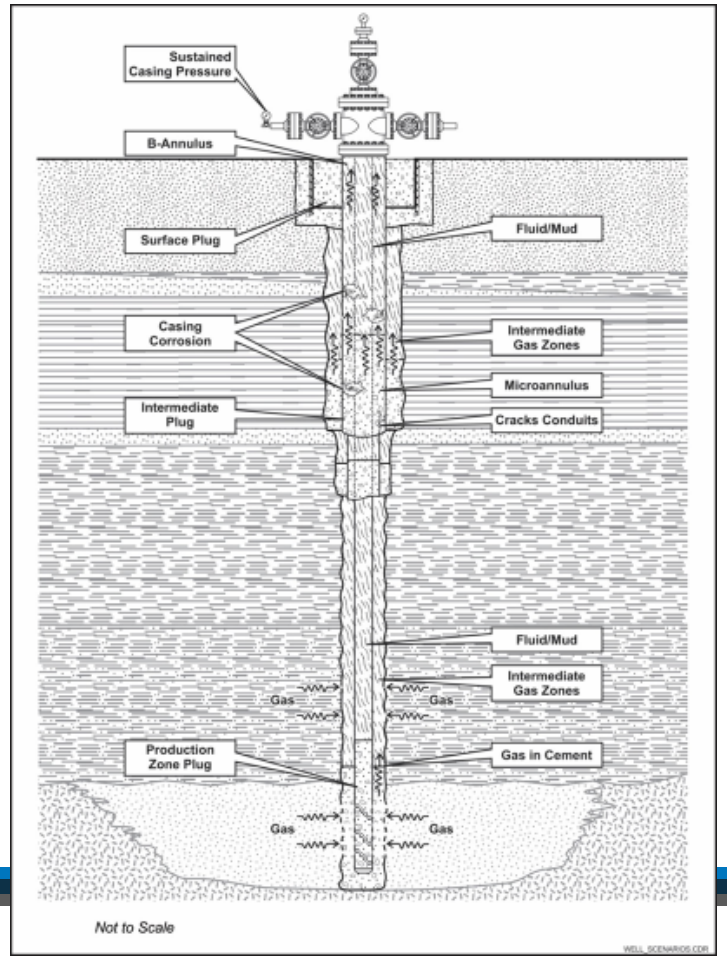
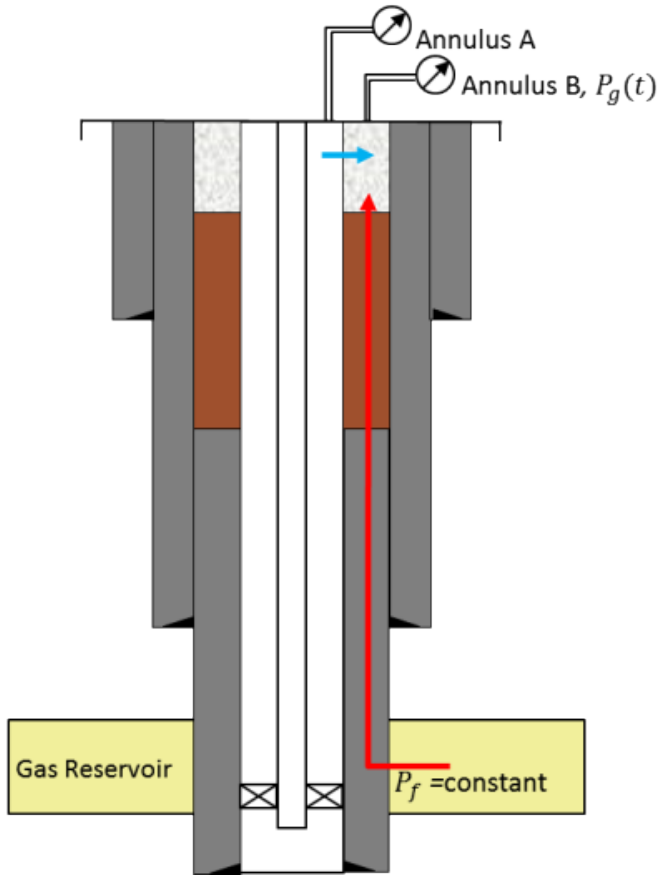
Well Integrity Testing

- Many possible types of well defects.
- Well defects may result in “sustained casing pressure” as gas migrates through casing/cement into ‘B’ annulus.





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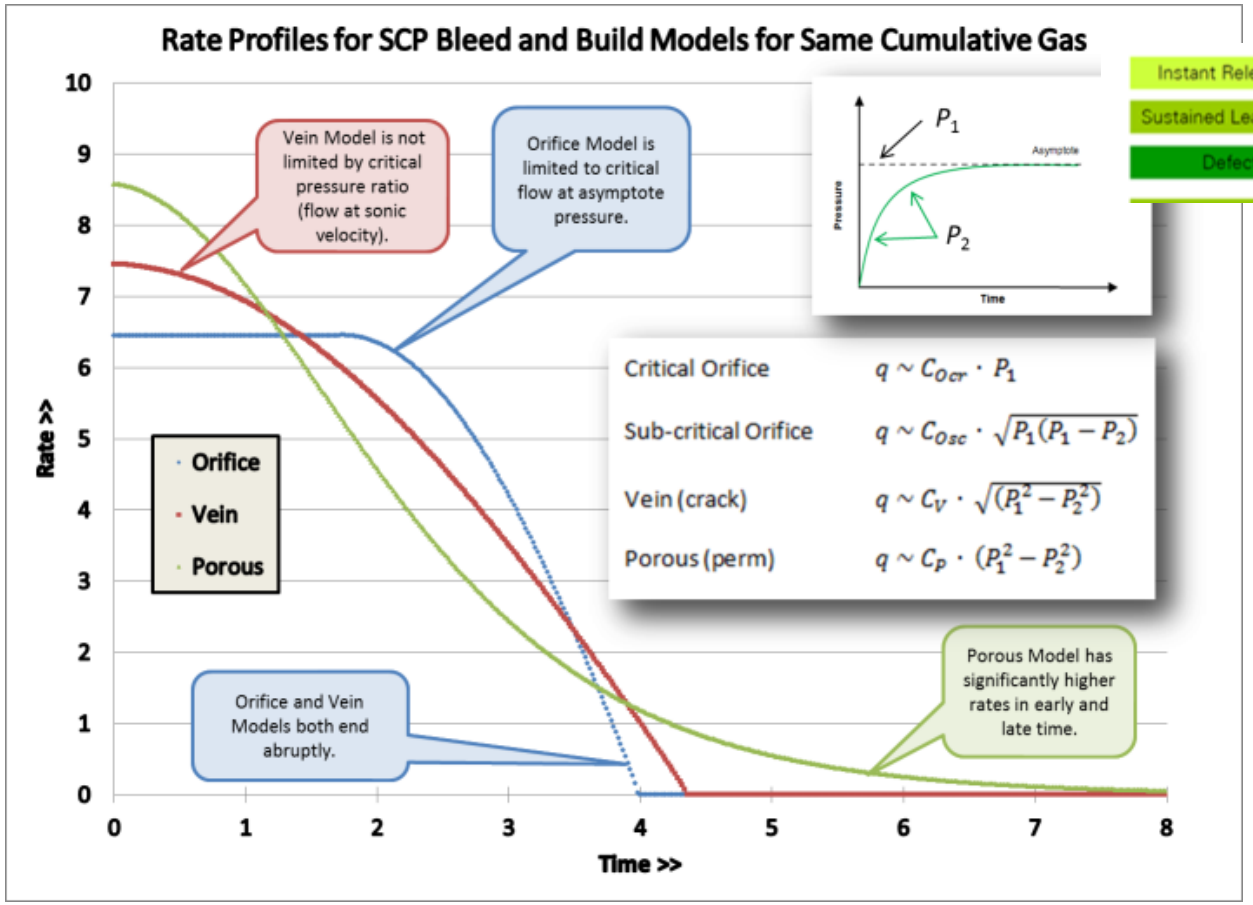
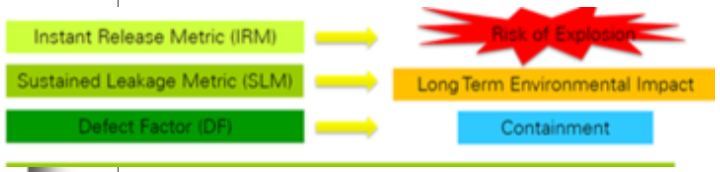
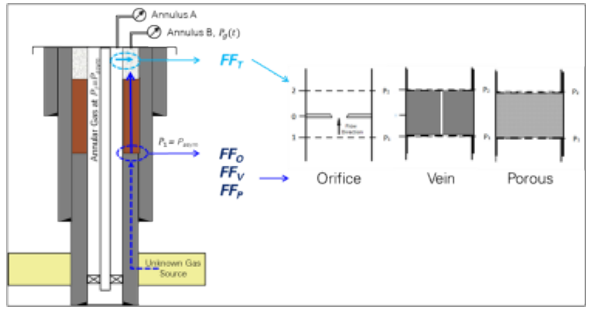
SCP Testing Methodology

- SCP testing analysis method provides measure of defect factor, nature of defect, and release metrics.







Sustained Casing Pressure Diagnosis Using the Wellhead Model, Mark Moody, Bryan Dotson, and Matthew Place, SPE/CSGM Gas Migration Challenges – Identification and Treatment Workshop, 13-14 May 2015, Banff, Alberta, CA.

Sustained Casing Pressure Diagnosis with Extended Data Collection, Matt Place, Glenn Larsen, Bryan Dotson, Nigel Jenvey, and Mark Moody, SPE Eastern Regional Meeting, 13-15 October 2015, Morgantown, West Virginia.

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SCP Testing Methodology

- SCP testing equipment and methods are routine for gas storage field operators.

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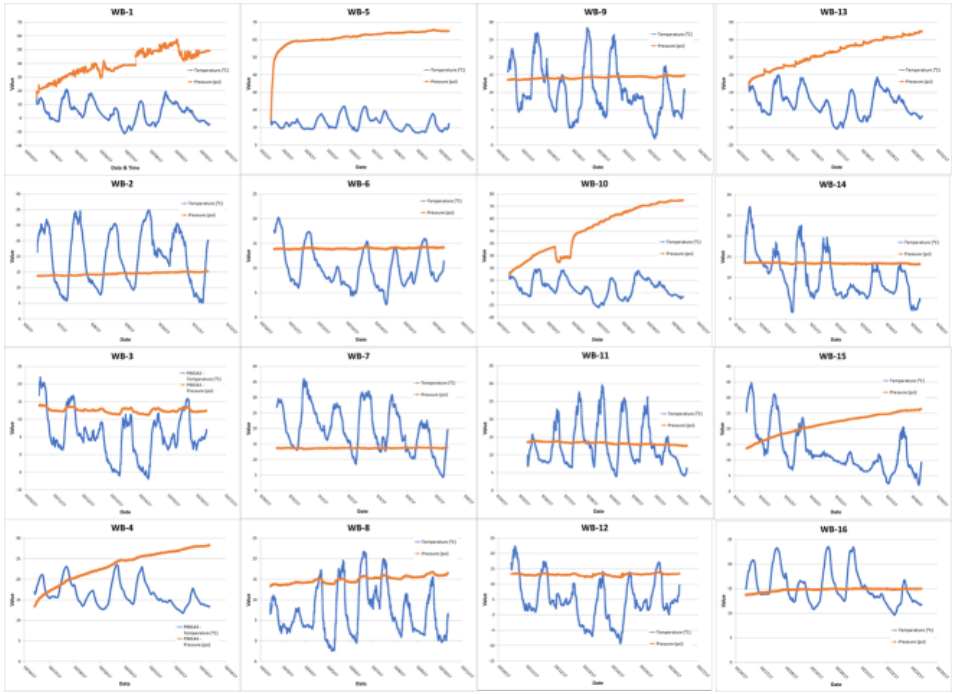
SCP Testing Methodology

- Sustained casing pressure testing kits were constructed to test wells using methodology by Moody et al., 2015.
- Allows operators to test many wells with a direct, non-invasive testing method (don't need to "kill" well).

Field SCP Data



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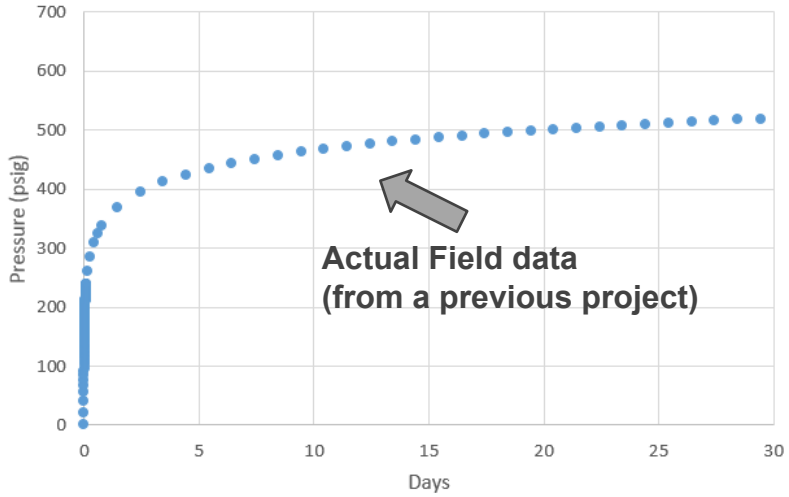
SCP Testing Methodology

- SCP testing procedure:
  - Confirm wellhead configuration!
  - Measure initial pressure on b-annulus
  - Vent gas and measure gas volume
  - Collect gas sample for analysis
  - Install pressure/temp logger
  - Log pressure build-up (1-8 weeks)
  - Remove logger
  - Analyze results
- No interruption in well operations!

Pressure Build-Up Monitoring



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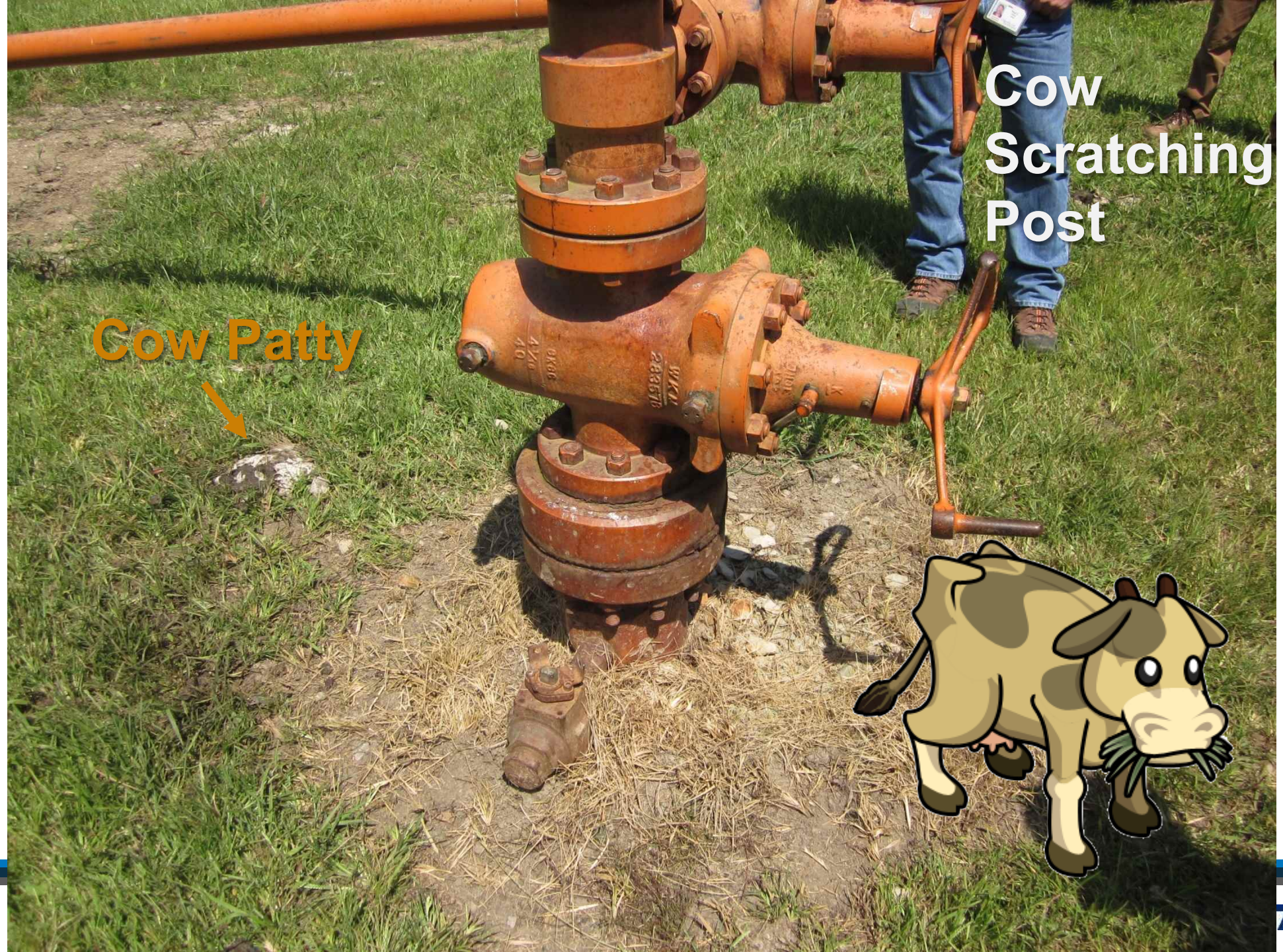
Cow Scratching Post
Cow Patty

Thanks!

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References

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- *Is your well flat or carbonated? What sustained casing pressure testing and beer have in common*. J.R. Sminchak. 11th IEAGHG Monitoring Network Meeting. June 13-15, Traverse City Michigan.
- *Field Testing and Well History Analysis on Wells Exposed to CO_2 in the Subsurface in the Midwest U.S.*, J.R. Sminchak, Mark Moody, Autumn Haagsma, Andrew Duguid, Matt Place, and Neeraj Gupta. Carbon Capture, Utilization, and Storage Conference, June 14-16, 2016, Tysons, VA, USA.
- A project overview presentation given by J.R. Sminchak at the DOE-NETL Carbon Storage Program Review Meeting in Pittsburgh, Pennsylvania, August 16-18, 2016.
- *Sustained Casing Pressure Diagnosis with Extended Data Collection*, **Matt Place**, Glenn Larsen, Bryan Dotson, Nigel Jenvey, and Mark Moody, SPE Eastern Regional Meeting, 13-15 October 2015, Morgantown, WV.
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- ***J.R. Sminchak**, Mark Moody, Andrew Theodos, Glenn Larsen, and Neeraj Gupta. 2014. Investigation of wellbore integrity factors in historical oil and gas wells for CO2 geosequestration in the Midwestern U.S. Energy Procedia (2014), pp. 5787-5797. http://dx.doi.org/10.1016/j.egypro.2014.11.611*