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McDonald, Jeffrey

From: Gilmore, Tyler J [Tyler.Gilmore@pnnl.gov]
Sent: Monday, March 03, 2014 1:02 PM
To: Roy, Stephen
Cc: Greenhagen, Andrew; Bayer, MaryRose; Smith, Robert H; Akhavan, Maryam; Deniz (Inci) Demirkanli; McDonald, Jeffrey; Williams, Mark D
Subject: Re: AoR delineation
Attachments: 2014-DCL-7PlumesMSHorError-SPILW-001_02-25[1].jpg; 2014-DCL-7PlumesMSVertError-SPILW-001_02-25[1].jpg; P and Sat at MWells-draft[2].docx; Wells_penetrating_Confining_Zone[1].png

Steve,

Attached are several files in response to Jeff's bullets below which we can talk through on our conference call today.

- Microseismic vertical sensitivity
- Microseismic horizontal sensitivity
- Predicted Pressure and CO2 saturation at monitoring well locations
- Map of wells penetrating the confining zone

We are also currently working on map showing the sensitivity of the deformation monitoring which we hope to have to you before the call. I will send this in a separate email.

Thanks

Tyler

From: <Roy>, Stephen <roy.stephen@epa.gov>
Date: Friday, February 28, 2014 1:10 PM
To: Tyler Gilmore <tyler.gilmore@pnnl.gov>, Jeff McDonald <mcdonald.jeffrey@epa.gov>, "Williams, Mark D" <mark.d.williams@pnnl.gov>
Cc: "Greenhagen, Andrew" <Greenhagen.Andrew@epa.gov>, "Bayer, MaryRose" <Bayer.MaryRose@epa.gov>, Vincent Vermeul <vince.vermeul@pnnl.gov>, "Smith, Robert H" <smith.roberth@epa.gov>, "Akhavan, Maryam" <Akhavan.Maryam@epa.gov>, "Deniz (Inci) Demirkanli" <Deniz.Demirkanli@cadmusgroup.com>, Alain HR Bonneville <alain.bonneville@pnnl.gov>, "Appriou, Delphine" <Delphine.Appriou@pnnl.gov>
Subject: RE: AoR delineation

Hello, Tyler,

I just scheduled a meeting from 1:30 – 2:30 pm (CST). Jeff will be out of town but Andrew, Rob and I will participate in Chicago. The call-in number is

1-866-299-3188

and the conference code is

2025640000.

Steve

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From: Gilmore, Tyler J [<mailto:Tyler.Gilmore@pnnl.gov>]

Sent: Friday, February 28, 2014 2:51 PM

To: McDonald, Jeffrey; Williams, Mark D

Cc: Greenhagen, Andrew; Bayer, MaryRose; Vermeul, V R (Vince); Roy, Stephen; Smith, Robert H; Akhavan, Maryam; Deniz (Inci) Demirkanli; Bonneville, Alain; Appriou, Delphine

Subject: RE: AoR delineation

Jeff and all,

I suggest we re-schedule for a call on Monday.

I'm missing my technical quorum due to a myriad of medical procedures and minor family emergencies today. It will also give us a chance to run the Nicot method over the weekend to understand the implications and be able to discuss those in more depth.

Could we tentatively plan for a call sometime between 10 and 4 (PST)?

Thanks

Tyler

From: McDonald, Jeffrey [mcdonald.jeffrey@epa.gov]

Sent: Friday, February 28, 2014 8:10 AM

To: Gilmore, Tyler J; Williams, Mark D

Cc: Greenhagen, Andrew; Bayer, MaryRose; Vermeul, V R (Vince); Roy, Stephen; Smith, Robert H; Akhavan, Maryam; Deniz (Inci) Demirkanli

Subject: RE: AoR delineation

Tyler,

I may not be able to make the call today, but I'd suggest still moving forward with it with Molly and Maryam from HQ, Inci at Cadmus, and Steve Roy and Rob Smith from our office.

We think we should discuss:

- Our rationale (beyond what I have stated so far) for needing to look at pressure beyond the projected plume footprint.
- That we are working to clarify the applicability of the Nicot method and understanding any limitations of it.
- Exploring PNNL's perspective on things like:
 - The result you get when applying the Nicot method
 - Limitations of a pressure defined AoR
 - Other options for an AoR defined by pressure

Again, I'm sorry I probably won't be able to make the call.

Jeff

Jeffrey R. McDonald, Geologist

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(312) 408-2240 [direct fax]

mcdonald.jeffrey@epa.gov

From: Gilmore, Tyler J [mailto:Tyler.Gilmore@pnnl.gov]
Sent: Friday, February 28, 2014 7:24 AM
To: McDonald, Jeffrey; Williams, Mark D
Cc: Greenhagen, Andrew; Bayer, MaryRose; Vermeul, V R (Vince)
Subject: RE: AoR delineation

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Morning Jeff,

Would it be possible to have a conference call later today to discuss this in more detail? Some of the conditions in the Nicot paper are not applicable to our site. For example

The FutureGen site does not conform to two of the four assumptions in the Nicot 2008 paper (pg. 49)

- a. Assumes system is "normally pressured"
- b. Assumes "no thief zone between the USDW and the injection formation"

The other two assumptions are that the borehole fluid temperature is in thermal equilibrium with the formations and that the formations are mostly flat.

We would like to discuss how we could satisfy the regulations by monitoring for pressure and as you alluded to in your message we will be measuring indicators of pressure beyond the area of the separate phase CO2 front with the deformation and microseismic approaches. We would like to understand if more is needed.

Thanks
Tyler

I'm traveling back to the northwest right now and hope to be available by phone sometime after noon (PST). Is it possible to have a call after that time today?

Thanks
Tyler

From: McDonald, Jeffrey [mcdonald.jeffrey@epa.gov]
Sent: Thursday, February 27, 2014 3:33 PM
To: Williams, Mark D
Cc: Gilmore, Tyler J; Greenhagen, Andrew; Bayer, MaryRose
Subject: AoR delineation

Mark,

Thanks for talking today about the FutureGen Alliance (FGA) project. As we discussed, the issue of how the AoR is defined for this project has been a subject of discussion internally and with PNNL. Some of the issues that have caused us concern are:

- the regulatory requirement to track the pressure front
- the relatively small AoR that the plume footprint would define compared to one defined by increased formation pressures
- the inconsistent approach if ADM uses the Nicot method and the FGA uses the Birkholzer method

Although using the Nicot method is likely to result in a large AoR, we think that this needs to be considered. I think the FGA/PNNL has looked at this large area already, so we hope this is not too great a burden. We need to talk about how pressure might be monitored in the Mt. Simon, in the near plume and distant areas. We have had some discussions with you and your colleagues on this issue this week and previously. A few of the items that we'd like FGA to provide (by Monday, 3/3/14 ideally) are:

- a complete list of wells that penetrate the confining zone within a Nicot method described AoR. We think this is the maximum extent of the 5 psi contour. That is, where the Mt. Simon might be expected to have 5 psi above the current formation pressure based upon the proposed injection when the contour is furthest from the project location.
- an expanded list of all the monitoring wells with their predicted pressure profiles (injection and post injection phases)
- details on their DINSAR monitoring

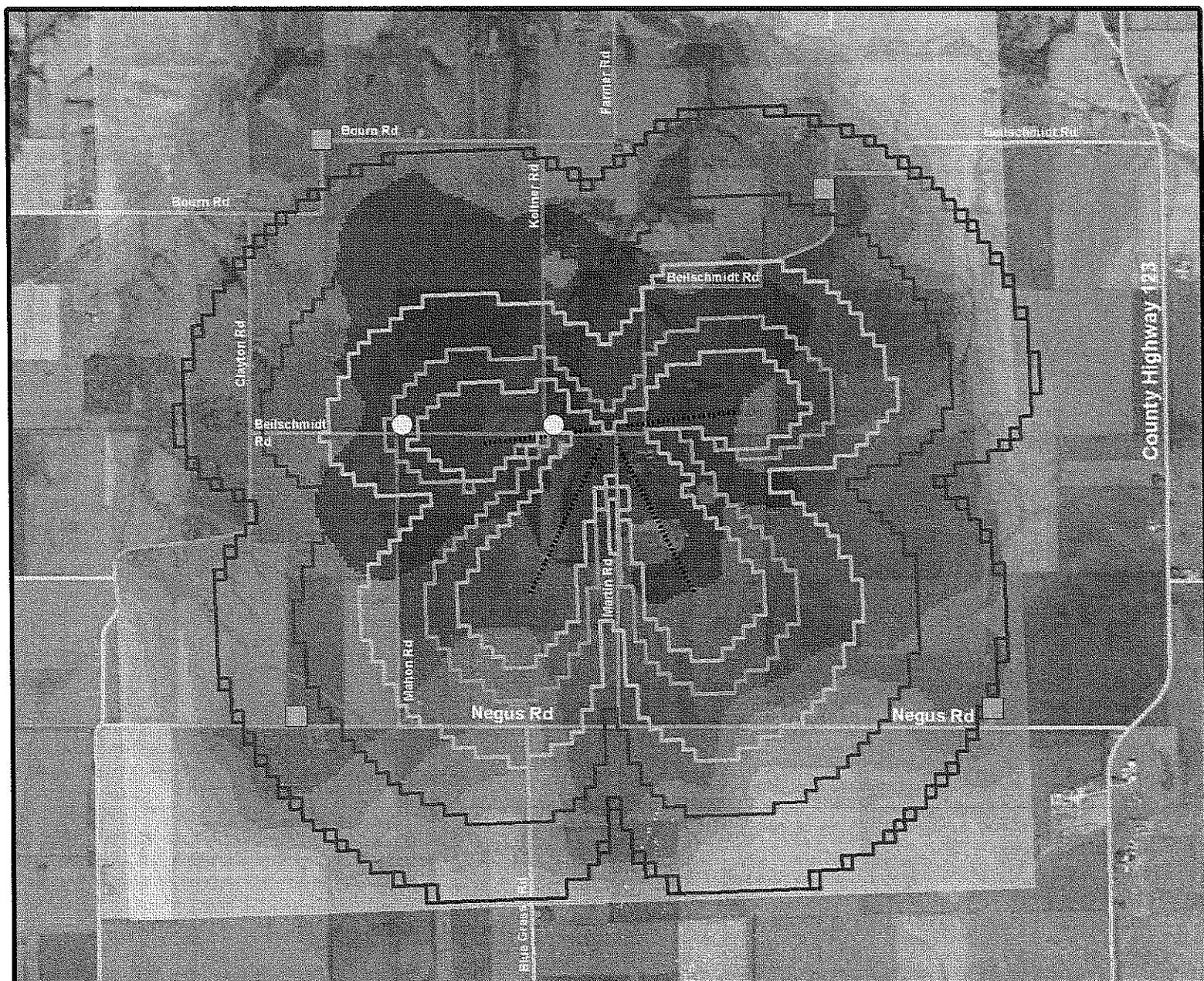
- how much area are you proposing to monitor?
- how sensitive this is to changes in pressure. Specifically, can you overlay changes in pressure with changes in surface deformation?
- Details on how far outside the plume the passive seismic monitoring can “see” and what resolution you expect with increasing distance.

Please correct me if I missed an issue that we discussed. As always, if you and Tyler have questions or comments, please let us know.

Thanks,

Jeff

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Microseismic
Vertical Error

- 13.36318016 - 33
- 33.00000001 - 66
- 66.00000001 - 100
- 100.00000001 - 133
- 133.00000001 - 166
- 166.00000001 - 200
- 200.00000001 - 233

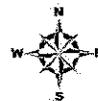
- 233.00000001 - 266
- 266.00000001 - 300
- 300.00000001 - 333
- 333.00000001 - 366
- 366.00000001 - 400
- 400.00000001 - 433
- 433.00000001 - 466
- 466.00000001 - 500

ARRAYTYPE DEEP SHALLOW

cm24_c2 model simulation - scCO₂ plume extent

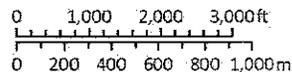
- Monitoring Period**
- 70-yr scCO₂ Plume (50yr Post-Injection)
 - 22-yr scCO₂ Plume (Maximum Extent)
- Injection Period**
- 20-yr scCO₂ Plume (Injection Ends)
 - 10-yr scCO₂ Plume
 - 5-yr scCO₂ Plume
 - 2-yr scCO₂ Plume
 - 1-yr scCO₂ Plume

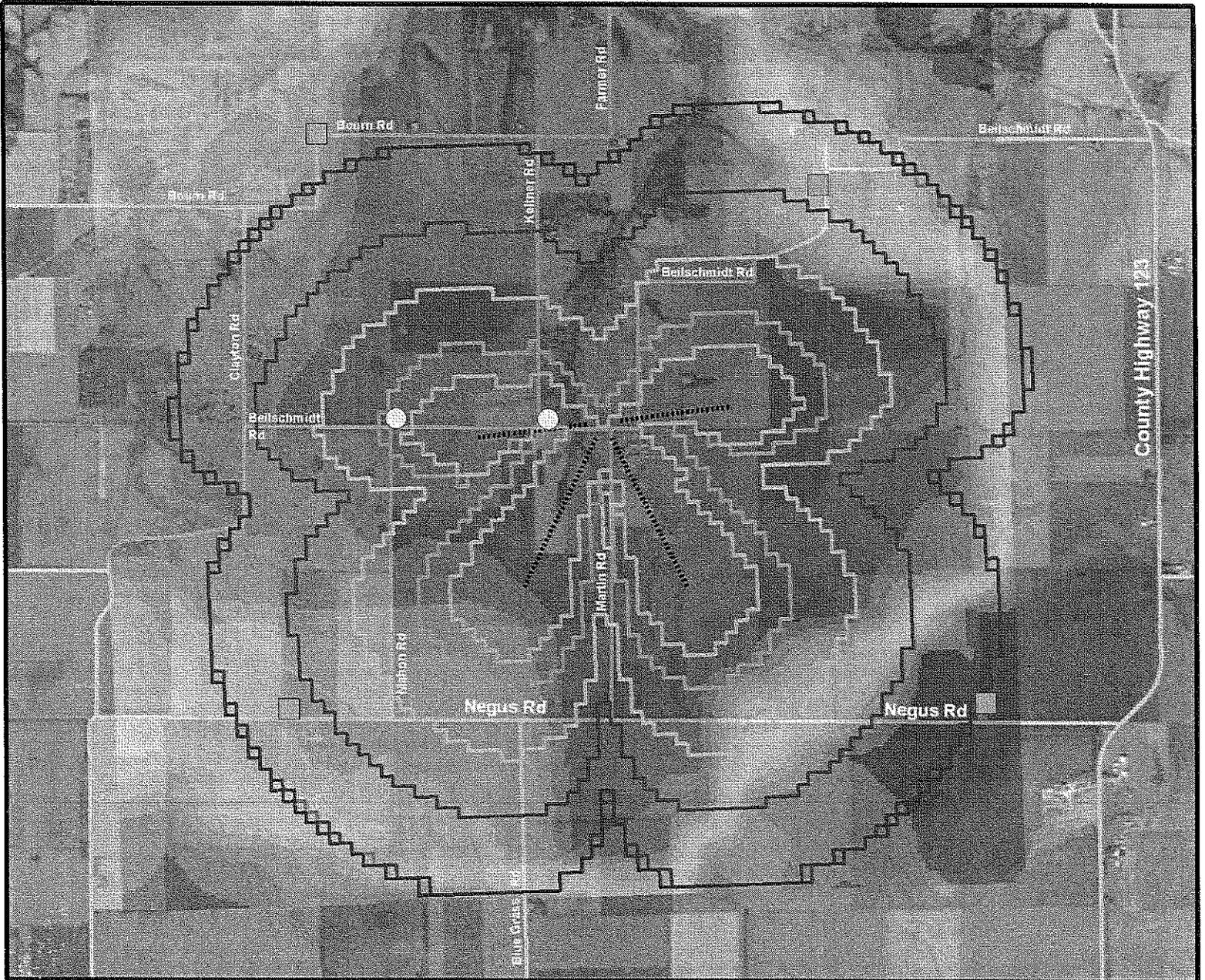
scCO₂ =
super critical
CO₂



..... Horizontal Injection Well

Map Projection: NAD1983
State Plane Illinois West (US ft)
1:40,000



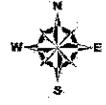


Microseismic Horizontal Error	ARRAYTYPE
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33.00000001 - 66	SHALLOW
66.00000001 - 100	
100.00000001 - 133	
133.00000001 - 166	
166.00000001 - 200	
200.00000001 - 233	
233.00000001 - 266	
266.00000001 - 300	
300.00000001 - 333	
333.00000001 - 366	
366.00000001 - 400	
400.00000001 - 433	
433.00000001 - 466	
466.00000001 - 525	

cm24_c2 model simulation - scCO₂ plume extent

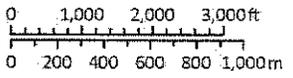
- Monitoring Period**
- 70-yr scCO₂ Plume (50yr Post-Injection)
 - 22-yr scCO₂ Plume (Maximum Extent)
- Injection Period**
- 20-yr scCO₂ Plume (Injection Ends)
 - 10-yr scCO₂ Plume
 - 5-yr scCO₂ Plume
 - 2-yr scCO₂ Plume
 - 1-yr scCO₂ Plume

scCO₂ =
super critical
CO₂



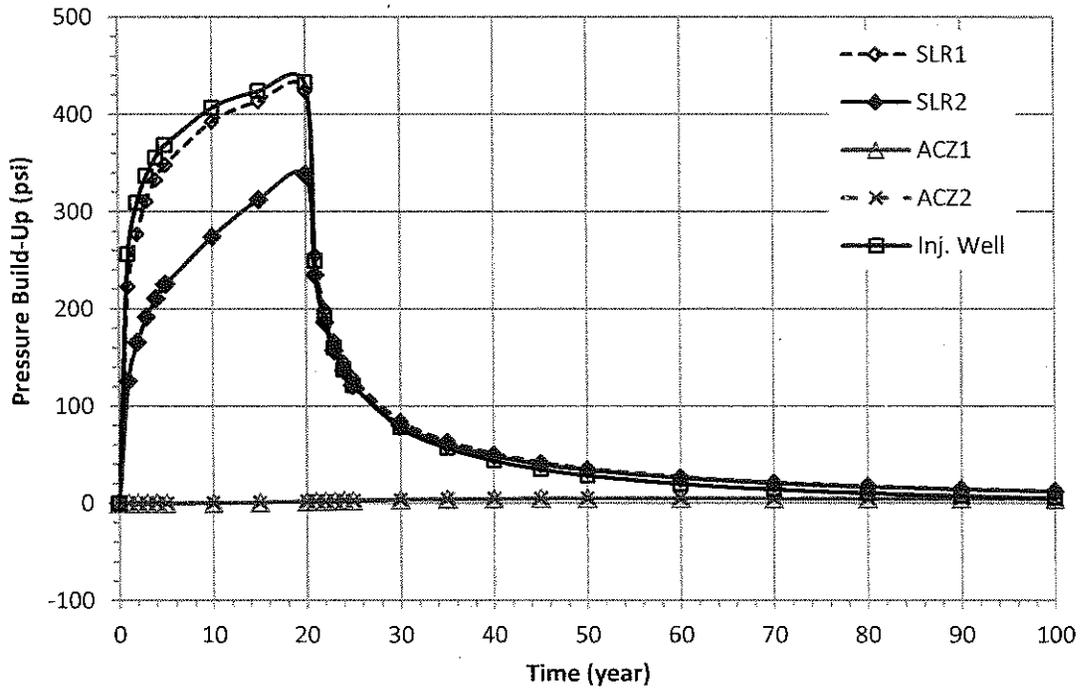
Horizontal Injection Well

Map Projection: NAD1983
State Plane Illinois West (US Ft)
1:40,000

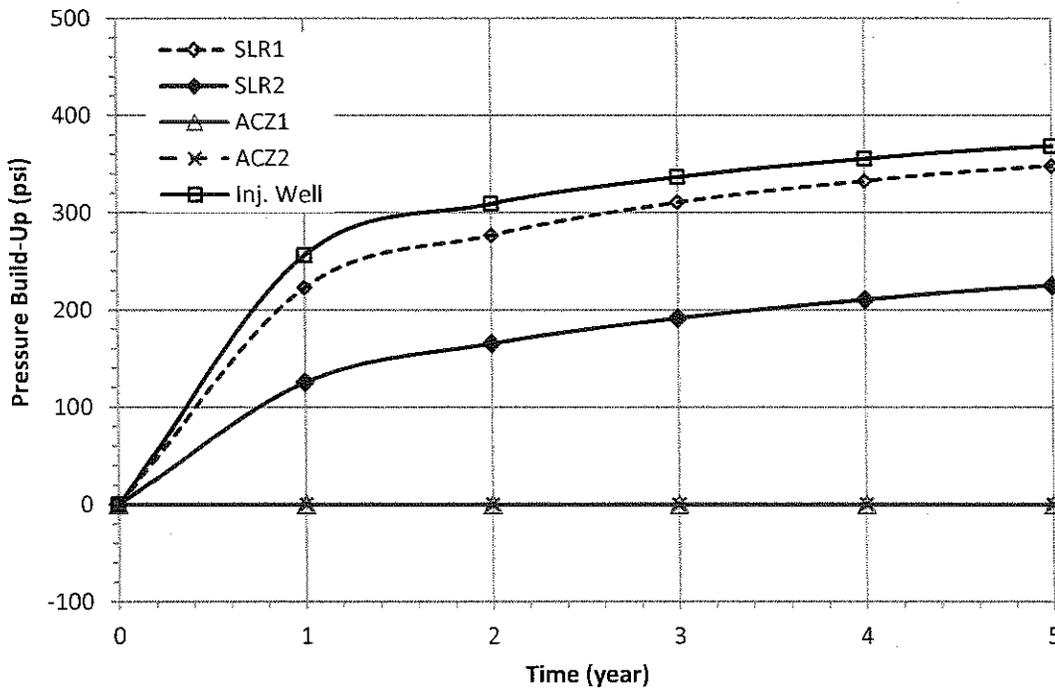


Aqueous pressure build-up at the monitoring wells and the CO₂ saturation at the RATs (draft)

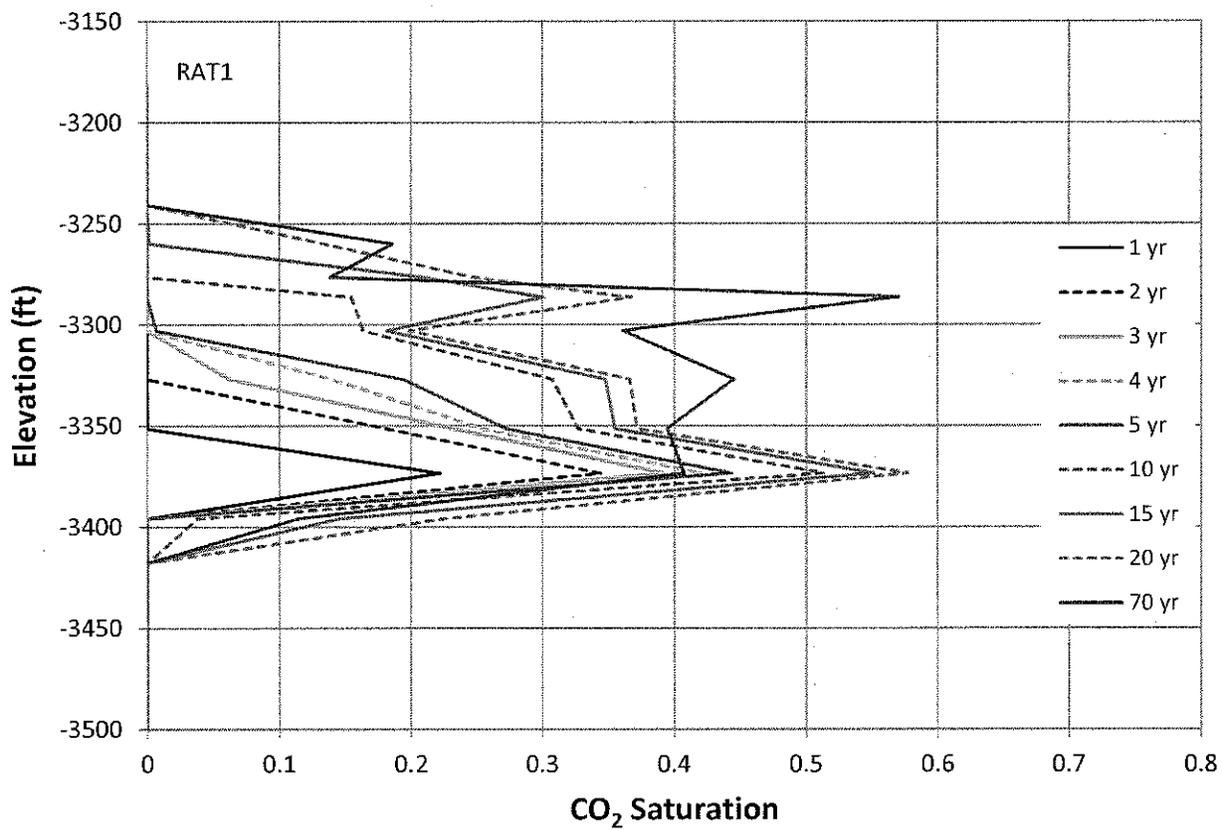
Prepared by Fred Zhang
2/24/14



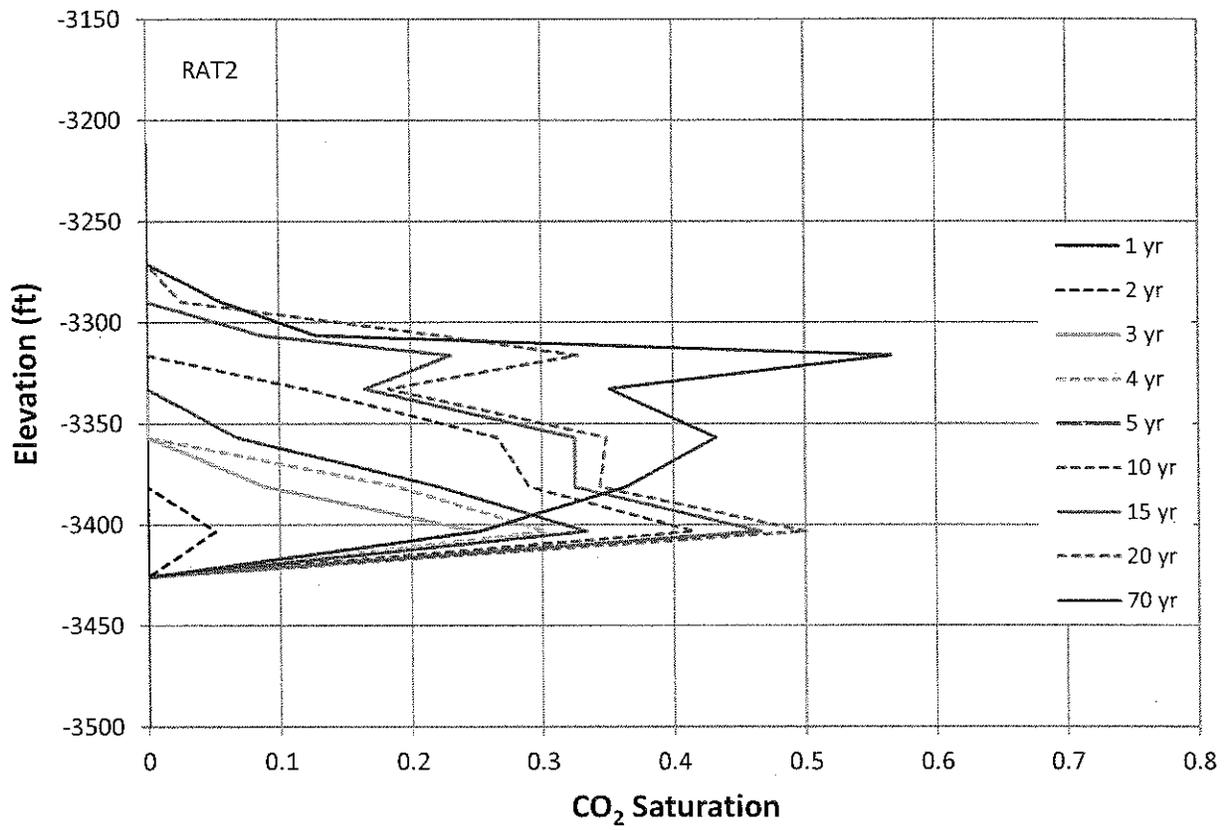
Aqueous pressure build-up time-course at the monitoring and injection wells



Aqueous pressure build-up time-course at the monitoring and injection wells during the first five years

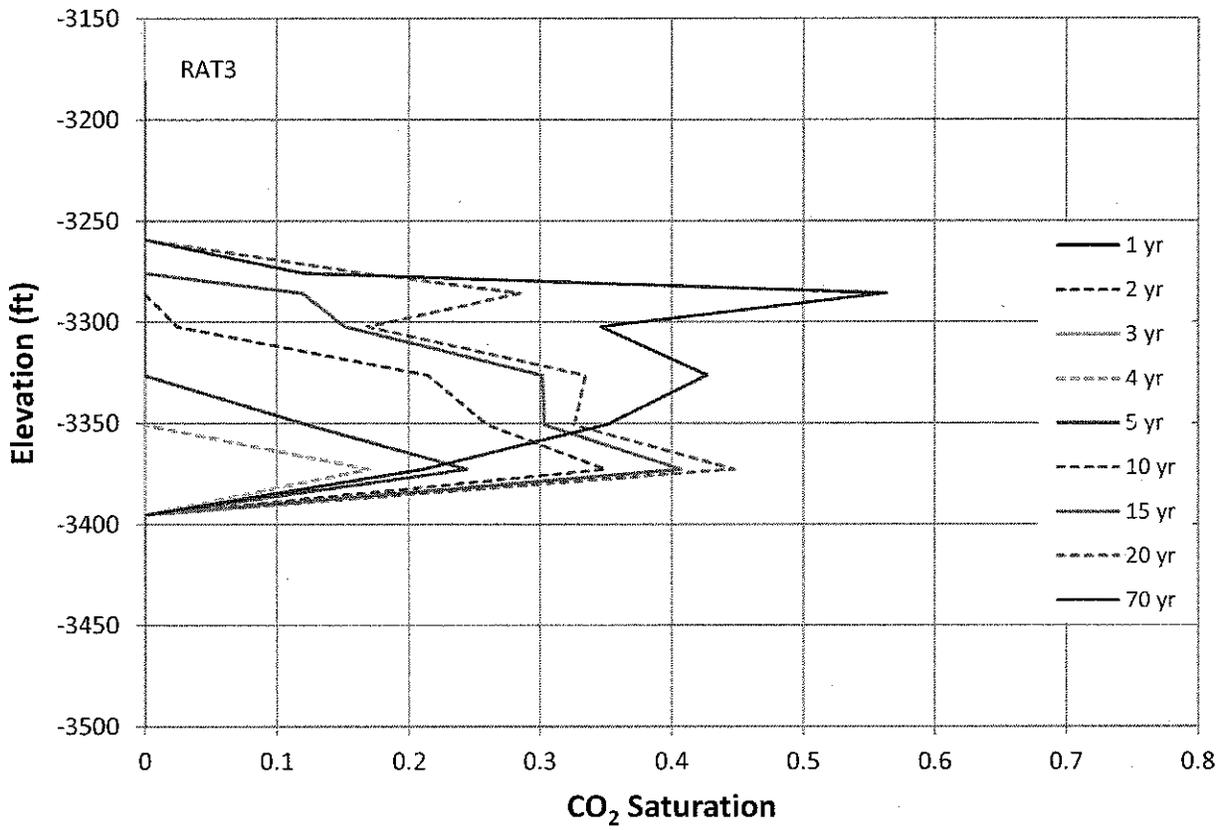


CO₂ saturation profile for well RAT1 at different times



CO₂ saturation profile for well RAT2 at different times

DRAFT



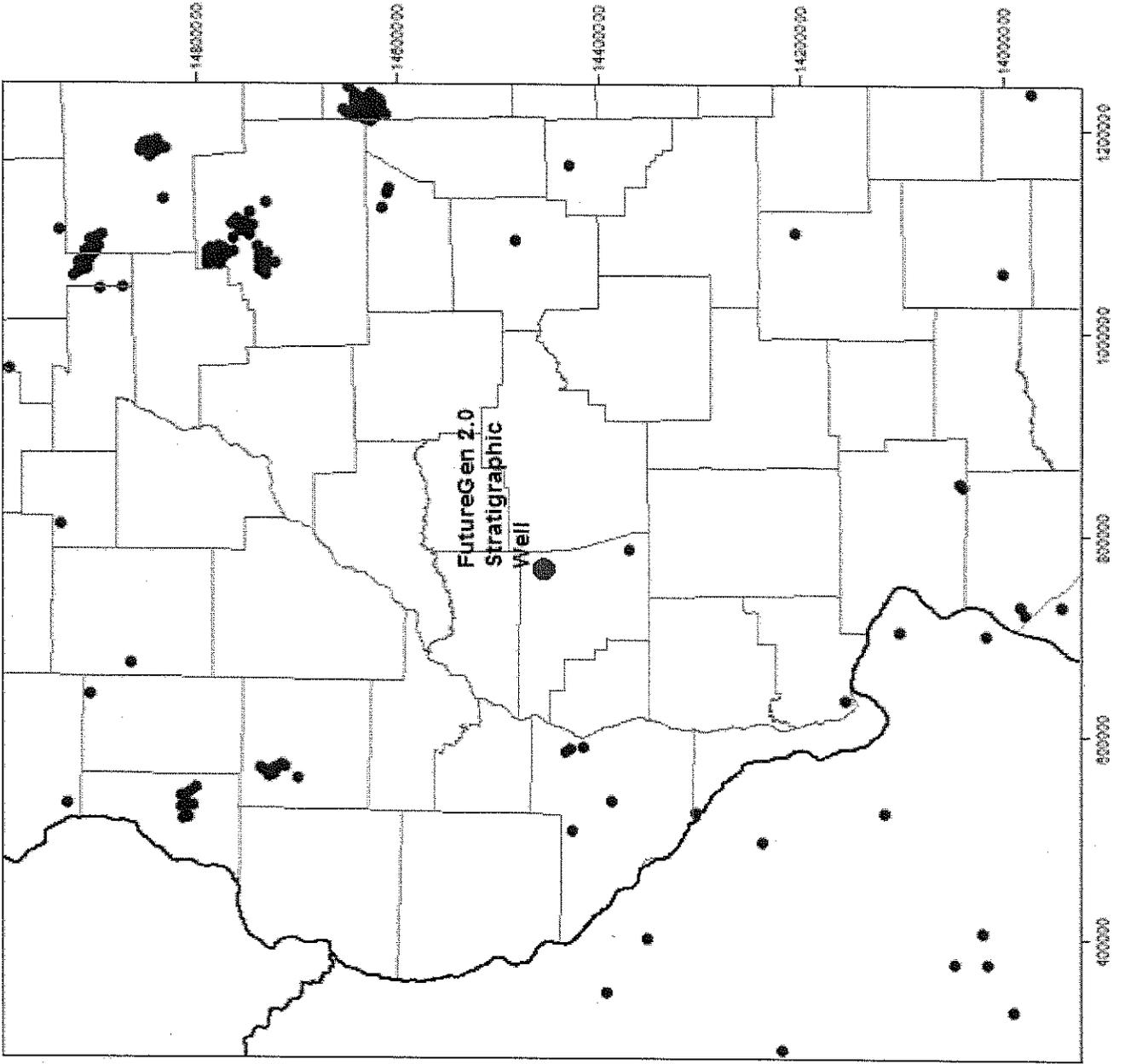
CO₂ saturation profile for well RAT3 at different times

DRAFT

Wells Penetrating the Confining Zone Surrounding the FutureGen 2.0 Site

Legend

- FutureGen 2.0 Stratigraphic Well
- Well Penetrating the Confining Zone



FutureGen 2.0
Date: 3/3/2014

The inset map shows the outline of the United States with a shaded rectangle highlighting the state of Illinois. Neighboring states are labeled: Michigan to the north, Indiana to the east, Kentucky to the southeast, Missouri to the southwest, and Iowa to the west.

Map Projection: NAD83
State Illinois West (US ft)

Two scale bars are provided. The top bar is in miles, with markings at 0, 10, 20, 40, and 60. The bottom bar is in kilometers, with markings at 0, 20, 40, and 60.

